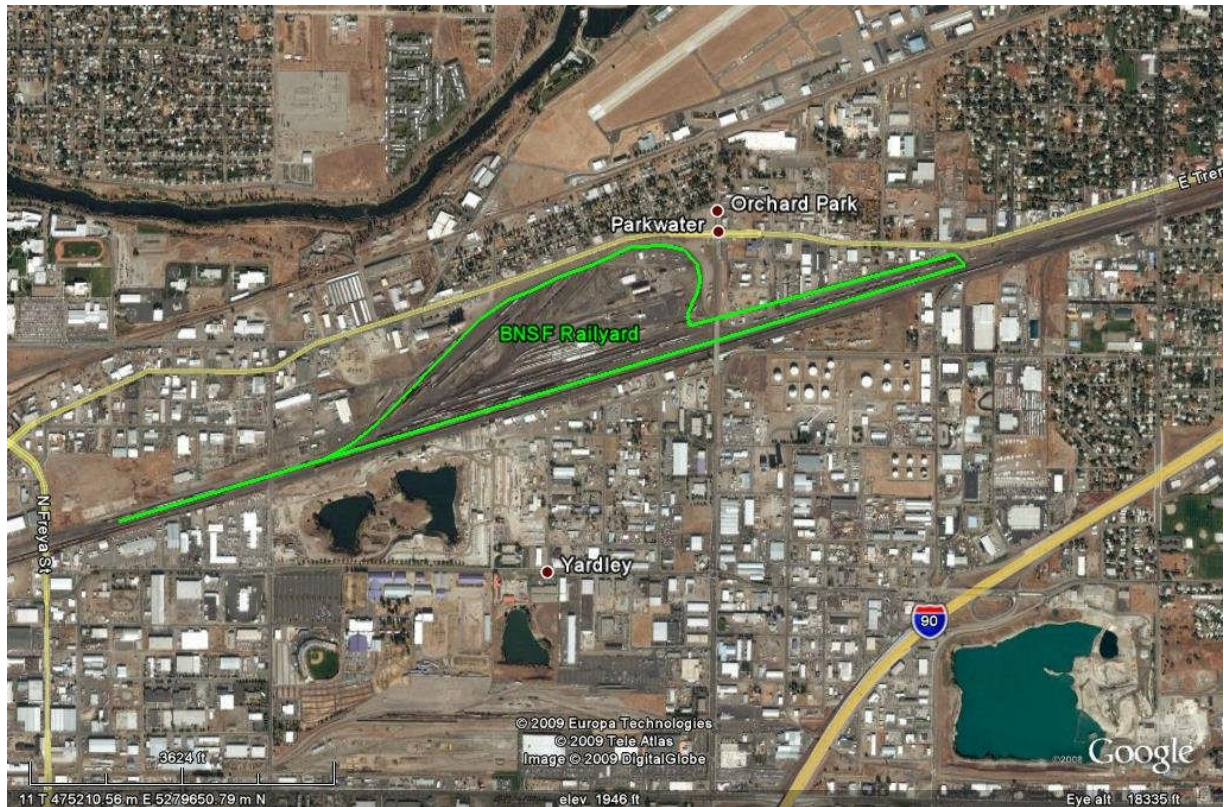


## Health Risk Study for the Burlington Northern / Santa Fe Railroad Spokane Railyard



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## **I. SRCAA MISSION AND POLICY STATEMENT**

SRCAA's mission is to preserve, enhance and protect the quality of Spokane County's air resource for the benefit of current and future generations.

Furthermore, it is SRCAA's declared public policy "to secure and maintain such levels of air quality that protect human health and safety, including the health and safety of the most sensitive members of the population, to comply with the requirements of the Federal Clean Air Act (FCAA)...

"to protect the public welfare, to preserve visibility, to protect scenic, aesthetic, historic, and cultural values, and to prevent air pollution problems that interfere with the enjoyment of life, property, or natural attractions."<sup>1</sup>

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<sup>1</sup> SRCAA Regulation I, Article I, Section 1.01 – Policy.

## **II. PREFACE**

The intent of this report is to address the possible Diesel Particulate Matter (DPM) cancer risk to the population surrounding the Burlington Northern Santa Fe (BNSF) railyard. It provides factual information to Spokane Regional Clean Air Agency's Director and Board so that they may determine a course of action, if any, concerning possible DPM cancer risk. It also highlights the present technologies available for controlling DPM from locomotives and switchers from railyards.

This report does not, and is not intended to, provide a specific plan for controlling DPM or other pollutants arising from BNSF's railyard located in the City of Spokane, but provides possible avenues to explore in controlling pollutants.

"Risk", "health risk", "health impact", etc. refers to risk associated with cancer caused by Diesel Particulate Matter only, unless otherwise indicated in the passage.

Unless otherwise defined differently in a section of this report, the acronyms in Section IV and definitions in Section V apply throughout this report.

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#### **IV. ACRONYMS USED IN THIS REPORT**

Unless a different meaning is clearly required by context; acronyms used in this report mean the following:

ARB	– California’s Air Resources Board
ASIL	– Acceptable Source Impact Level
BNSF	– Burlington Northern Santa Fe Company
DPM	– Diesel particulate matter
DOH	– Washington State Department of Health
EPA	– United States Environmental Protection Agency
HAP	Hazardous Air Pollutant
HRA	– Health Risk Assessment
IRIS	– Integrated Risk Information System (EPA)
NAAQS	– National Ambient Air Quality Standard
NO <sub>x</sub>	– Nitrogen Oxides
NSR	– New Source Review
PM <sub>2.5</sub>	– Particulate Matter 2.5
PM <sub>10</sub>	– Particulate Matter 10
SO <sub>2</sub>	– Sulfur Dioxide
SRCAA	– Spokane Regional Clean Air Agency
SRHD	– Spokane Regional Health District
TAP	– Toxic Air Pollutant
UP	– Union Pacific
VOC	– Volatile Organic Compound

## V. DEFINITIONS USED IN THIS REPORT

Unless a word or phrase is defined within a paragraph or section; or a word or phrase is clearly defined differently by context; words, and phrases used in this report mean the following:

“Acceptable Source Impact Level” means a screening concentration of a toxic air pollutant in the ambient air as listed in WAC 173-460-150.

“Carbon Monoxide” is a compound consisting of one carbon atom and one oxygen atom.

“Carcinogen” means a cancer-causing substance or agent

“Centroid or Emissions Centroid” means in the context of this report, the point at which the total emissions of source are concentrated such that, considering the shape, wind speed and direction, topography surrounding the source and other modeling parameters, results in a series of isopleths of a pollutant’s cancer risk around that point.

“Criteria Pollutant” means a pollutant for which there is established a National Ambient Air Quality Standard (NAAQS) in 40 CFR Part 50. The criteria pollutants are carbon monoxide (CO), particulate (PM<sub>10</sub> & PM<sub>2.5</sub>), ozone (O<sub>3</sub>), sulfur dioxide (SO<sub>2</sub>), lead (Pb), and nitrogen dioxide (NO<sub>2</sub>).

“Concentration” as used herein, means a measured amount of an air pollutant present in a measured amount a gas or carrier medium usually expressed in units of measurement: of µg/m<sup>3</sup> (micrograms per cubic meter), ppm (parts per million) or ppb (parts per billion), as appropriate.

“Diesel Particulate Matter” means a mixture of particles that is a component of diesel exhaust.

“Emissions Inventory” means a database that lists, by source, the amount of air pollutants discharged into the atmosphere of a community during a given time period.

“Ecology” means the Washington State Department of Ecology.

“EPA” as it relates to this report means the federal agency empowered to enforce and implement the Federal Clean Air Act (42 USC 7401, et seq.).

“Hazard Index” means the ratio of a hazardous air pollutant concentration divided by its Reference Concentration, or safe exposure level.

“Hazardous Air Pollutant” means any air pollutant listed in or pursuant to Section 112(b) of the Federal Clean Air Act, 42 U.S.C. §7412.

“Isopleth” means a line that is mapped around a specific point which results from a certain value being the same.

“Median” means a number in a list of numbers where half the numbers in the list are less, and half the numbers are greater. It is normally used in place of the average when the list of numbers has a high variation of value throughout the list.

“Micron” means 1 millionth of a meter and 3.94 hundred thousandths of an inch.

“Mutagen” means an agent, such as a chemical, ultraviolet light, or a radioactive element, that can induce or increase the frequency of mutation in an organism.

“National Ambient Air Quality Standard (NAAQS)” means ambient air quality an health based standard set by EPA at 40 CFR Part 50 and includes standards for carbon monoxide (CO), particulate matter (specifically PM<sub>10</sub> and PM<sub>2.5</sub>), ozone (O<sub>3</sub>), sulfur dioxide (SO<sub>2</sub>), lead (Pb), and nitrogen dioxide (NO<sub>2</sub>).

“Nitrogen Oxides” means a compound consisting of nitrogen and oxygen atoms.

“New Source” means essentially the construction, installation, establishment, or modification of a stationary source that increases the amount of any air contaminant emitted by such stationary source or that results in the emission of any air contaminant not previously emitted.

“New Source Review” means a preconstruction permit review that applies to the construction and operation of new and modified stationary sources to ensure that a new source, modified existing, temporary/portable source or replacement of control technology complies with applicable federal, state, and local air pollution laws, rules, and/or regulations.

“Order of Approval” means a regulatory order issued by SRCAA to approve the installation of a proposed new source or modification, or the replacement or substantial alteration of control technology at an existing stationary source.

“Ozone” means a compound consisting of three oxygen atoms and at ground level is also referred to as “smog”

“PM<sub>2.5</sub>” means particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers.

“PM<sub>10</sub>” means particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers.

“Screening Model” means an air dispersion model that produces estimates of "worst-case" 1-hour air pollutant concentrations for a single source, without the need for meteorological data. It also includes conversion factors to estimate "worst-case" 3-hour, 8-hour, 24-hour, and annual concentrations.

“Sulphur Dioxide” means a compound consisting of sulphur and two oxygen atoms

“Nonroad Engine Tiers” means differing nonroad emissions standards aimed at improving the emissions from newly manufactured nonroad engines over specific time frames according to the size and use of the engine. The Tiers range from Tier 1 through Tier 4. The standards began implementation in 1996 and continue over a 20 year period.

“Toxic Air Pollutant” means any toxic air pollutant listed in WAC 173-460-150.

“TSCREEN” is an EPA model for screening criteria and toxic air pollutant concentrations.

“Volatile Organic Compounds” are compounds consisting hydrogen, carbon and various other atoms as defined by EPA in 40 CFR 51.100.

## VI. EXECUTIVE SUMMARY

Burlington Northern Santa Fe Company operates a railyard in Spokane, WA. Bill Dameworth, Spokane Regional Clean Air Agency's Director, requested that a study be performed to determine the approximate Diesel PM<sub>2.5</sub> (DPM) cancer risk that the population in the vicinity of the BNSF railyard might experience.

SRCAA investigated the following four methods in making a plausible determination of the cancer risk.

- A. California's Air Resources Board DPM cancer risk assessment completed for Stockton, CA as an approximation to Spokane, WA DPM cancer risk.

The application of Stockton's UP railyard cancer risk assessment to Spokane's BNSF railyard indicates the approximate cancer risk to the number of exposed residents and workers surrounding the BNSF railyard at the distance indicated in the following table:

Distance to BNSF Railyard Emissions Centroid	Population Possibly Exposed	Approximate Cancer Risk (per million)
0 - 900 feet	500 – 600	50 to 100
900 feet – 1 mile	2600	25 - 50
1 Mile – 2 miles	6450	10 - 50

- B. Washington Department of Health 2004 Lung Cancer Cluster Study for the interval 1992 – 2003.

A report of this study is not available. However, what is available consists of the boundaries of the study area and the number of cases of lung cancer within the study area and interval for the cluster study. When overlaid on a map, the boundaries of the study generally coincide with a two-mile radius surrounding the BNSF railyard's emissions centroid. The two-mile radius is approximately the 10 per million cancer risk isopleth resulting from the above application of Stockton UP railyard's DPM cancer risk assessment to the Spokane BNSF railyard.

- C. Washington Department of Health 2010 cancer cluster study for the interval 1992-2006.

The DOH's 2010 cancer cluster investigation found that the population living in the Hillyard Area, which is adjacent to the BNSF railyard, experiences a statistically significant 40% increase in lung cancer incidence when compared with Washington State's expected cases of lung cancer from 1992 - 2006.

SRCAA reviewed a number of factors that were presented in DOH's investigation that could be considered to cause or contribute to the increased occurrence of lung cancer in Hillyard. The factors included cigarette smoking, radon, vehicular traffic, a regional airport, and industrial sources, including some industrial sources that are either no longer in existence or are very insignificant emitters of air pollutants.

SRCAA reviewed each factor to determine whether or not the factors listed in DOH's investigation appeared to contribute to the 40% differential between the Hillyard area's actual cancer occurrences and the State's average occurrence and eliminating those factors from further review and then trying to determine those factors that could account for the differential.

After comparing the factors as they related to Hillyard and other areas of the Spokane metroplex, it was determined that there was no supporting evidence that the Hillyard areas was more exposed to the DOH listed factors than any other part of Spokane's metroplex. In fact, there was evidence that certain areas of the Spokane metroplex might be more exposed to diesel traffic than Hillyard. The one factor that was not

common to other areas of the Spokane metroplex was Hillyard's close proximity to the BNSF railyard, indicating that it could be the main contributing cause of the lung cancer differential.

D. SRCAA 2005 Toxic Monitoring Study performed at four monitoring sites in Spokane.

Three monitoring sites are in the immediate vicinity the BNSF railyard (BNSF sites) while one of the sites (SRHD) represents a relatively clean (background) site compared to the other sites (dirty sites) associated with industrial, residential, mobile, and non-mobile emission sources.

SRCAA wanted to determine the differential increase of each of the toxic emissions as measured at each BNSF site compared to the less impacted SRHD site. These differential toxic emissions increases are due to industrial, residential, mobile, and non-mobile emission sources .

All of the following toxic pollutants below are tracer pollutants (i.e. air pollutants that are present in diesel exhaust) which were monitored in the 2005 toxic study and can be specifically associated with diesel combustion and are typical of emissions generated at the BNSF's railyard.

**Monitored Toxics Pollutants Typical to the BNSF Railyard**

Gases

- 1,3-Butadiene
- Acetaldehyde
- Formaldehyde

Metals

- Arsenic
- Beryllium
- Cadmium

Summarizing, in the areas around the BNSF railyard the 2005 toxic monitoring study's toxic emissions increase apportioned to BNSF's railyard operations, depending upon the monitoring site, appear to account for between 3 – 27% of the 1,3-butadiene (Avg. 12%), 4 – 15% of the acetaldehyde (Avg. 8%), and 11 – 27 % of the formaldehyde (Avg. 21%) gases and for metals, 7 – 37% of the arsenic (Avg. 19%), 9 – 28 % of the beryllium (Avg. 17%), and 12 – 17% of the cadmium (Avg. 15%).

Although the 2005 toxic monitoring study did not involve the measurement of DPM, the above monitored toxic pollutant emissions are closely linked with DPM emissions because they strongly adhere to the fine particulate (PM<sub>2.5</sub>) carbon atoms in the diesel exhaust.

DPM is deeply inhaled into the lungs and because of its extremely small particulate size is, for the most part, not cleaned out by lung's normal cleansing mechanisms. Therefore, the persistent presence of these and other TAPs in the lung have been proven to be a significant contributor to cancer risk for exposed populations.

## **VII. INTRODUCTION**

Bill Dameworth, Spokane Regional Clean Air Agency's (SRCAA) Executive Director, attended a California Air Resources Board (ARB) presentation on diesel particulate matter (DPM) emission health impacts to 17 California city populations living or working in close proximity for extended periods of time to California railyards.

Mr. Dameworth was concerned about the DPM health impacts from the Burlington Northern Santa Fe (BNSF) and Union Pacific (UP) railyards in Spokane and requested staff to determine approximately what the DPM health impacts might be from SRCAA's two railyards.

SRCAA contacted ARB requesting information concerning the DPM risk assessments that they had performed for the California's railyards. ARB explained that the DPM risk assessments that they performed for the 17 California cities' railyards involved approximately 75 people working over a 3 - 4 month period and that the study was very expensive. Mr. Dameworth determined that performing similar DPM cancer risk assessments was beyond SRCAA's funding and staff expertise. Therefore, he directed staff to take the existing ARB DPM cancer risk assessments and adapt them to Spokane's railyards in order to obtain approximations of the possible cancer health risk to the public residing around the railyards.

ARB recommended that SRCAA perform a DPM emissions inventory for the BNSF railyard and provide them with the inventory and information concerning the closeness of the railyard to residential and industrial areas and they would be willing to find a match to one of California's railyards.

ARB reviewed SRCAA's information and determined that the railyards in Stockton, CA were very close matches to Spokane's railyards. The Stockton BNSF and UP railyards are in close proximity to each other as are Spokane UP and BNSF railyards. Numerous other similarities related to the two cities' railyards are identified later in this report.

### **A. Why is SRCAA concerned about diesel PM emissions?**

The United States Environmental Protection Agency (EPA) has established health-based standards for two sizes of particles: PM<sub>10</sub>--which are particles 10 microns and smaller and PM<sub>2.5</sub>--which are particles 2.5 microns and smaller.

Diesel exhaust is primarily made up of PM<sub>2.5</sub>. It is a complex mixture of gaseous pollutants and fine particles that include over forty cancer causing substances. Among these are benzene, arsenic and formaldehyde. Diesel exhaust also contains several regulated air pollutants such as nitrogen oxides and volatile organic carbons which contribute to the formation of ozone which is commonly known as "smog".

Diesel PM<sub>2.5</sub> is more toxic than other forms of PM<sub>2.5</sub> such as wood smoke and poses a more serious health risk because of its toxicity. It can be breathed deep into the lungs where it remains lodged and can cause very serious health effects even at levels much lower than what air quality standards allow.

Exposure to diesel PM<sub>2.5</sub> causes both immediate and long-term health effects. Healthy children and adults become more at risk for respiratory diseases. People with pre-existing heart disease or circulatory problems are more likely to have a heart attack or stroke. Short-term exposure to diesel exhaust can irritate the eyes, nose, and throat, and cause coughing, labored breathing, chest tightness, and wheezing. Diesel exhaust can also lead to lung cancer, as well as cancers of the bladder and soft tissues.

Numerous health studies have been performed related to the emissions of diesel particulate. It is not the intent of SRCAA to reproduce those studies. However, it is important for people to understand the health effects associated with emissions from diesel engines. Instead, SRCAA will simply quote some studies and papers that have been generated concerning the subject.

For more information about diesel PM emissions, refer to the papers and brochures quoted hereafter.

*"Diesel exhaust has been strongly linked to many major chronic and/or terminal ailments. These include cancer, emphysema, auto-immune disorders, asthma, stroke, heart and lung conditions of all types, and the underdevelopment of children's lungs.*

*Fine particles in diesel exhaust penetrate our lungs and remain there indefinitely to create and/or worsen both lung and heart conditions.*"<sup>2</sup>

*"Studies show an association between exposure to diesel exhaust and lung cancer, as well as cancers of the bladder and soft tissues (Guo et al., 2004). The immune suppressing effects of diesel exhaust can also increase the susceptibility to cancer among those exposed. Several extensive and detailed reviews have been conducted on the body of literature relating long-term exposure to diesel exhaust particles and lung cancer (California EPA, 1998; USEPA, 2002; Cohen and Nikula, 1999). In addition, over 40 studies conducted among those populations exposed to diesel exhaust have found increased rates of lung cancer associated with diesel exhaust particles exposure (Cohen and Nikula, 1999)..."<sup>3</sup>*

*"Exposure to diesel PM is a health hazard, particularly to children whose lungs are still developing and the elderly who may have other serious health problems. In addition, the diesel PM particles are very small. By mass, approximately 94 percent of these particles are less than 2.5 microns in diameter (PM<sub>2.5</sub>). Because of their tiny size, diesel PM is readily respirable and can penetrate deep into the lung and enter the bloodstream, carrying with them an array of toxins. Population-based studies in hundreds of cities in the U.S. and around the world demonstrate a strong link between elevated PM levels and premature deaths (Pope et al., 1995, 2002 and 2004; Krewski et al., 2000), increased hospitalizations for respiratory and cardiovascular causes, asthma and other lower respiratory symptoms, acute bronchitis, work loss days, and minor restricted activity days (ARB, 2006e).*

*Diesel PM emissions are the dominant toxic air contaminant (TAC) in and around a railyard facility..."<sup>4</sup>*

*"Composition of diesel exhaust*

*The characteristics of exhaust emitted from the combustion of diesel fuel vary according to the combustion conditions. Diesel exhaust is a complex mixture composed of particulate and gaseous components. Important gaseous components include carbon dioxide (because of its 'greenhouse' effect), carbon monoxide, sulfur oxides, nitrogen oxides, and 18,000 identified volatile and semivolatile hydrocarbon compounds. Carbon particles adsorb the majority of these compounds, which may enhance their ability to become lodged in lung tissues. Over 98% of the particles are less than 2.5 microns in diameter, and approximately 94% of those particles are less than 1 micron in diameter (California Air Resources Board, 1998). The hydrocarbon compounds adhere to these minute carbon particles during the combustion process.*

*The diesel exhaust particles component consists mainly of elemental carbon particles with large surface area, which adsorb numerous hydrocarbons. These hydrocarbons include carcinogenic polycyclic aromatic hydrocarbons, aldehydes, and other chemical agents. Diesel exhaust particles can also undergo atmospheric transformation after they have been emitted. For example, polycyclic aromatic hydrocarbons adhered to carbon particles may react with hydroxyl*

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<sup>2</sup> WA State Department of Ecology, "Wahington State Clean Diesel Grant Program," Wahington State Clean Diesel Grant Program Brochure, Revision 4/08 ed.,: 2.

<sup>3</sup> Harriet Ammann, PhD DABT; Matthew Kadlec, PhD DABT, Concerns about Adverse Health Effects of Diesel Engine Emissions, White Paper., Publication No. 08-02-032, (Washington State Department of Ecology, December 3, 2008) 22.

<sup>4</sup> Chan, Pham, et. al., Health Risk Assessment for the Union Pacific Railroad Stockton Railyard, Report, (California Air Resources Board, (November 19, 2007) 75.

radicals in the air, and create highly mutagenic and carcinogenic nitro-polycyclic aromatic hydrocarbons (Cohen and Nikula, 1999)”<sup>5</sup>

## **B. Health Risk Assessments (HRAs) (Simplified Description)**

*“A health risk assessment uses mathematical models to evaluate the health impacts from exposure to certain chemical or toxic air contaminants [In this case cancer risk HRAs for DPM] released from a facility [e.g. railyards] or found in the air. HRAs provide information to estimate potential long term cancer and non-cancer health risks. **HRAs do not gather information or health data on specific individuals, but are estimates for the potential health impacts on a population at large** [emphasis SRCAA’s]....*

*The potential cancer risk from a given carcinogen [A cancer-causing substance or agent.] estimated from the health risk assessment is expressed as the incremental number of potential cancer cases that could be developed per million people, assuming population is exposed to the carcinogen at a constant annual average concentration over a presumed 70-year lifetime....*

*The HRA is a complex process that is based on current knowledge and a number of assumptions. However, there is a certain extent of uncertainty associated with the process of risk assessment. The uncertainty arises from lack of data in many areas necessitating the use of assumptions. The assumptions used in the assessments are often designed to be conservative on the side of health protection in order to avoid underestimation of risk to the public.”<sup>6</sup>*

## **C. Stockton BNSF and Spokane UP railyards Comparison**

ARB determined that the Stockton BNSF railyard was very similar to Spokane’s UP railyard, in that each railyard has minimal activity within the railyard and is used primarily for storage of railcars with no switching or other equipment within the railyards. The emissions from these two sites are nearly equivalent and are minor compared to the other larger railyard. ARB found that the Stockton BNSF railyard had insignificant risk to the population and thus was not included in the ARB study; therefore, because of the similarities, SRCAA did not include the Spokane UP railyard in this study for the same reason.

In general, an insignificant risk means that the pollutant’s impact will result in no adverse health risk to the population being studied. Ecology in WAC 173-460-090(7) describes an “insignificant risk” as:

“Ecology may recommend approval of a project [that]...demonstrates that the increase in emissions of TAPs is not likely to result in an increased cancer risk of more than one in one hundred thousand [Equivalent to 10 in a million cancer risk]...” ARB uses the same cancer risk as Ecology.

## **D. Stockton’s UP railyard with Spokane’s BNSF railyard Comparison**

The Stockton Union Pacific (UP) railyard employs many different operations at their site, including haul line, switching operation, repairs, and other activities; therefore, ARB concentrated their efforts on the UP railyard.

The operations being performed at Spokane’s BNSF railyard are very similar to those of the Stockton UP railyard. In addition, the emissions from Spokane’s BNSF railyard are very similar to Stockton’s UP railyard. Therefore, SRCAA concentrated its efforts on the Spokane BNSF railyard.

### **What do the two railyards and cities have in common?**

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<sup>5</sup> Harriet Ammann, PhD DABT; Matthew Kadlec, PhD DABT, Concerns about Adverse Health Effects of Diesel Engine Emissions, White Paper., Publication No. 08-02-032, (Washington State Department of Ecology, December 3, 2008) 22.

<sup>6</sup> Edited from Chan Pham, et. al., Health Risk Assessment for the Union Pacific Railroad Stockton Railyard, (10/19/2007; California Air Resources Board, 2007) 2.

1. Each city has two railyards that impact residential health.
  - a. UP Stockton has residential areas immediately to the east and west,
  - b. UP Spokane has residential areas immediately to the south.
  - c. BNSF Stockton has residential areas immediately to the north and southwest,
  - d. BNSF Spokane has residential areas immediately to the north and northwest,
2. The railyards in both cities are located in industrial areas.
3. Spokane's UP railyard activities are similar to Stockton's BNSF railyard.
4. Spokane's BNSF railyard activities are similar to Stockton's UP railyard.
5. The two railyards in both cities are in close proximity to each other (< 1 mile).
6. The railyards in both cities are in close proximity to residential areas (< 1000 feet).
7. The railyards have equivalent types and quantities of operating equipment.
8. Diesel PM emissions are comparable for the UP Stockton and BNSF Spokane railyards, 6.82 and 5.9 tons/year, respectively.
9. The metropolitan populations (2006) are approximately the same (Stockton – 439,2770 and Spokane – 446,706).
10. The topographical areas surrounding the railyards are relatively flat.
11. The average annual wind speeds are approximately the same, Stockton 7.5<sup>7</sup> and Spokane – 8.9<sup>8</sup> mph averaged over 42 and 55 years, respectively.
12. The wind directions, although different, blow toward the affected residential areas.
13. Stockton covers 60.9 mi<sup>2</sup>, while the City of Spokane covers 58 mi<sup>2</sup>.

## **VIII. STOCKTON CANCER RISK RESULTS**

ARB describes the near-source and regional source cancer risks in Figures 1 and 2.

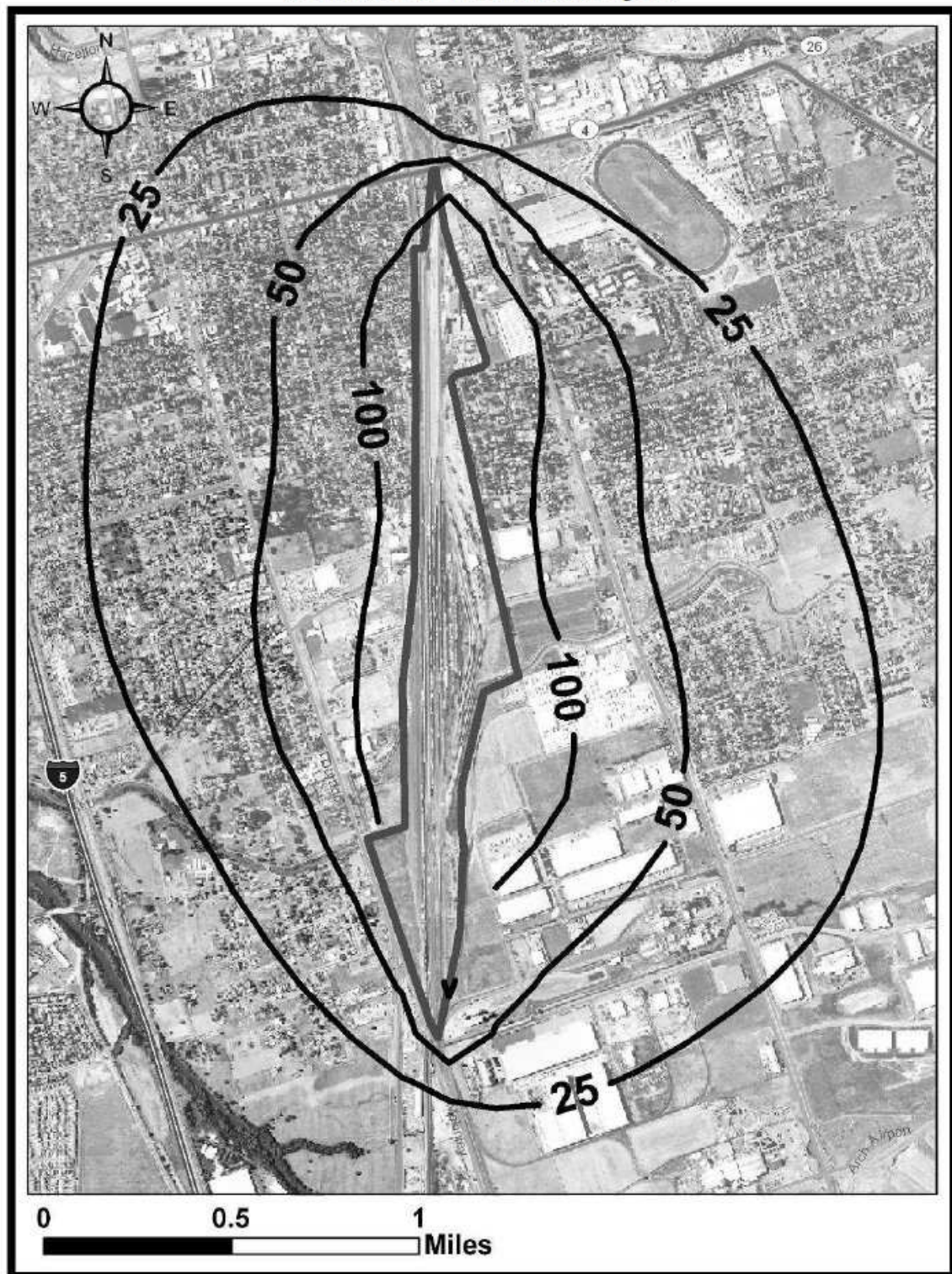
“As indicated in Figure 1, at locations within 200 yards of the UP Stockton railyard boundary, the estimated cancer risks are about 100 chances per million. At about a half mile from the UP Stockton railyard boundaries, the estimated cancer risk is about 50 chances per million, and within a mile of the railyard boundary the estimated cancer risks range from 50 to 25 chances per million. As indicated by Figure 2, the risks further decrease to about 10 chances per million within a 2 mile distance from the railyard boundaries.”<sup>9</sup>

<sup>7</sup> <http://www.ncdc.noaa.gov/oa/climate/online/ccd/avgwind.html> (8/31/2011)

<sup>8</sup> <http://www.ncdc.noaa.gov/oa/climate/online/ccd/avgwind.html> (8/31/2011)

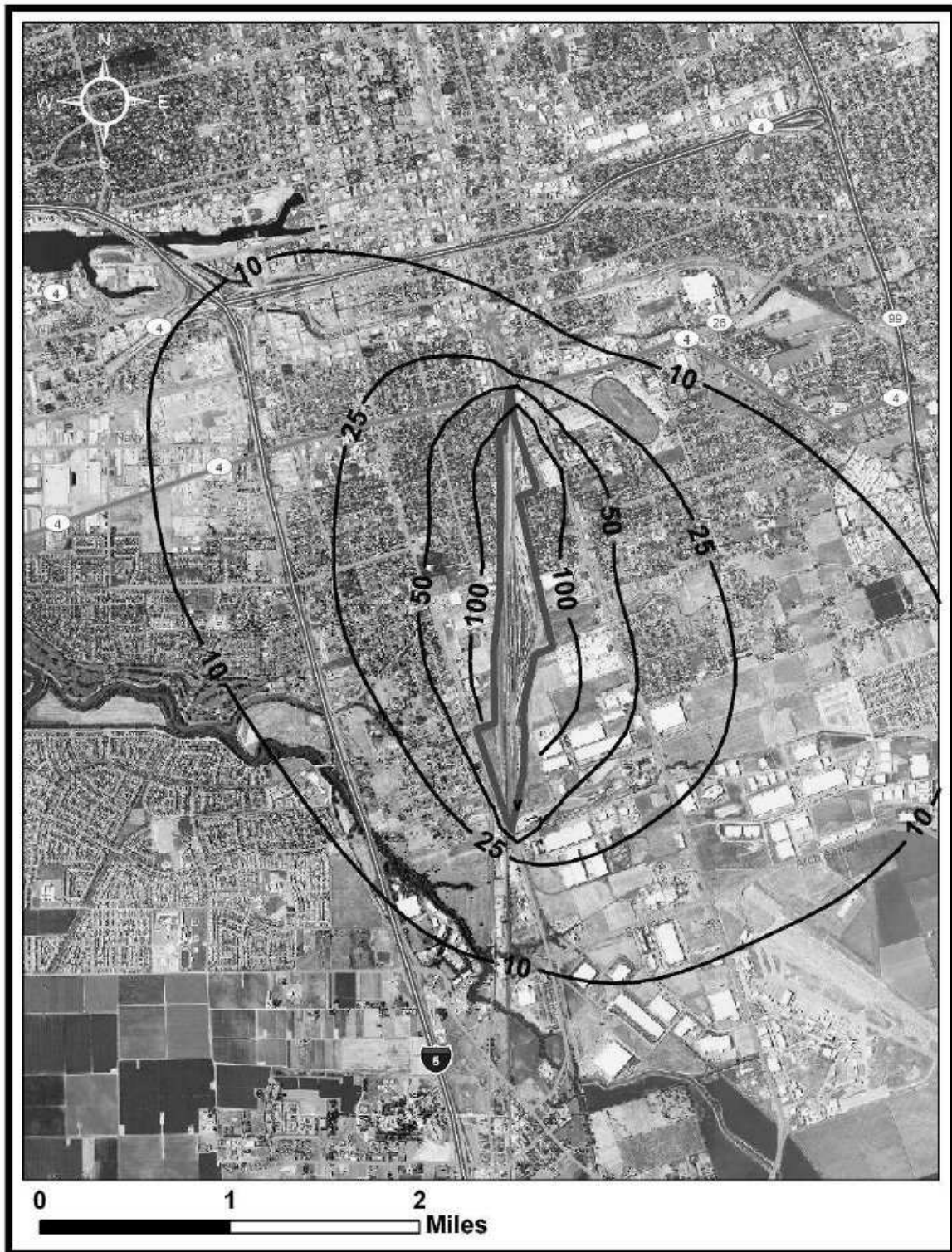
<sup>9</sup> Chan Pham, et al., , Health Risk Assessment for the Union Pacific Railroad Stockton Railyard,: 15-16, 18.

**Figure II-2: Estimated Near-Source Cancer Risks (chances per million people)  
from the UP Stockton Railyard**



**Figure 1 Estimated Near-Source Cancer Risks from the UP Stockton Railyard  
(Chances per million)**

**Figure II-3: Estimated Regional Cancer Risks (chances per million)  
from the UP Stockton Rail yard**



**Figure 2 Estimated Regional Cancer Risks from the UP Stockton Rail yard  
(Chances per million)**

An isopleth is a line that is mapped around a specific point which results from a certain value being the same. A good example of an isopleth is a line that is mapped for a specific elevation (e.g. 1,000 ft) on a geographical contour map. The same can be mapped for equal risk factors around a specific point, in this case the BNSF emissions centroid.

Based on Figures 1 & 2, the shape of the UP Railyard appears to influence the 100 and 50 chances per million cancer risk isopleths more than the wind direction and speed; while the 25 chance per million cancer risk isopleth appears to be affected by the UP Railyard shape to a certain extent; however the influence of the prevailing northwesterly wind direction (wind direction from NW to SE) and wind speed (7.5<sup>10</sup> mph) is becoming more apparent. The wind direction and speed appears to heavily influence the 10 per million cancer isopleth's shape.

#### **IX. SPOKANE BNSF RAILYARD ANNUAL CRITERIA AND TOXIC POLLUTANT<sup>11</sup> EMISSIONS INVENTORY AND MODELING.**

As was mention earlier in this report, SRCAA's development of an emissions inventory was necessary in order for ARB to find a good match between their 17 cities with railyards and Spokane. **NOTE: Emission inventories are not health risk assessments, but could be used as information to perform health risk assessments; however, the Spokane BNSF railyard's emissions inventory was only used as a tool in matching up the Spokane BNSF railyard to one of the 17 California railyards.**

Emissions inventories of various air pollutants are primarily determined using emission factors. Emission factors provided by BNSF to Ecology were used to determine the air pollutant emissions associated with BNSF's railyard.

Emissions factors have long been a fundamental tool in developing national, regional, state, and local emissions calculations for making air quality management decisions and in developing emissions control strategies.

An emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., pounds of volatile organic compounds emitted per 1000 gallons of diesel burned). Such factors facilitate estimation of emissions from various sources of air pollution.

Emission factors originate from a variety of sources, such as, an average of numerous source tests for a source category, actual source tests of the air pollution source, from Material Safety Data Sheets (MSDS), etc. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category.

The criteria and toxic pollutant emissions for the Spokane BNSF railyard were calculated for 2005 based on information provided by the Washington State Department of Ecology's (Ecology) Emissions Inventory Department. In addition, SRCAA requested an emissions inventory from BNSF. The emissions from both are comparable.

#### **Comparison of the existing BNSF railyard to the expected emissions as if it were a "new stationary source".**

SRCAA Regulation I, Article V is SRCAA's new source review regulation and chapter 173-460 WAC is Ecology's new source review regulation for toxic air pollutants (TAP). Under Article V, criteria pollutants for new sources are reviewed to determine whether or not a controlled criteria pollutant exceeds the allowable NAAQS limits for that pollutant. NAAQS are federal criteria pollutant health based standards.

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<sup>10</sup> <http://www.ncdc.noaa.gov/oa/climate/online/ccd/avgwind.html> (8/31/2011)

<sup>11</sup> Criteria pollutant, hazardous air pollutant, and toxic air pollutant are defined in Appendix A,

Similarly chapter 173-460 WAC establishes acceptable source impact levels (ASIL) for toxic air pollutants, which are indicators of possible health risks if the ASIL is exceeded. If SRCAA's toxic review indicates that a controlled TAP emission exceeds its ASIL and can not be resolved by SRCAA, then a health risk assessment must be performed by Ecology for the TAP. As in the case of criteria pollutants, Ecology having to perform a health risk assessment is extremely rare.

Although the BNSF railyard is not subject to new source review, SRCAA decided to model the BNSF railyard to see if a NAAQS or an Ecology TAP ASIL would be exceeded, which could indicate a possible health risk for the criteria and toxic air pollutants. SRCAA typically uses an EPA conservative screening model "TSCREEN" to determine property line and maximum concentrations of criteria and TAPs when doing new source review. If a modeled criteria air pollutant or TAP meets the relevant federal or state standard, then according to EPA and Ecology, one can be reasonably assured that the pollutant being reviewed will not pose a health risk to the population.

In additions, SRCAA used on-line information supplied in BNSF's annual reports to calculate the emissions inventory for the 2007 projections.

Toxic air pollutant emissions were modeled based on the latest May 2009 version of chapter 173-460 WAC.

The following tables (1 - 4) summarize the 2005 and projected 2007<sup>2</sup> expected actual emissions and NAAQS and toxic pollutant modeling status. The air pollutants in the following tables are those that were included in the 2005 emissions inventory submitted by BNSF to Ecology.

At the time that the report was originally drafted, some of the non-criteria air pollutants in the inventory were subject to the pre-May 2009 chapter 173-460 WAC revisions; however, after the May 2009 chapter 173-460 WAC revisions those air pollutants were no longer considered to be toxic by Ecology. They are still part of the emissions inventory and are included in the tables, but their property line and maximum concentrations have not been evaluated.

The May 2009 chapter 173-460 WAC revisions excluded many of the federal hazardous air pollutants (HAPS) previously included, so those pollutants that are considered HAPs, but are not now included in chapter 173-460 WAC do not have ASILs. However, they are still included in the emissions inventory and are still listed in the tables.

In addition, most if not all, of the non-criteria pollutants in the tables are listed in EPA's IRIS database, which is a tool used by EPA and other agencies for performing risk assessments. Because EPA considers them to be toxic enough to include in the IRIS database, they are still included in the emissions inventory and tables,

#### **BURLINGTON NORTHERN SANTA FE (BNSF) RAIL YARD LINE HAUL AND SWITCH YARD EMISSIONS INVENTORY (EI)<sup>4</sup>**

**Table 1 BNSF Railyard Criteria Pollutant Emissions (based on emission factors)**

<b>Criteria Pollutant of Concern</b>	<b>2005 Total Tpy<sup>1</sup></b>	<b>Projected 2007 Total Tpy<sup>2</sup></b>	<b>Do Projected 2007<sup>2</sup> Concentrations Exceed NAAQS? If so, by what factor?</b>
Carbon Monoxide (CO)	25.5	27	<b>No</b>
Nitrogen Oxides (NOx)	215	227.3	<b>1.52</b>
PM <sub>10</sub> <sup>3</sup>	4.4 (diesel) 6.1 (total)	6.5 (diesel) 7.3 (total)	<b>No</b>
PM <sub>2.5</sub> <sup>3</sup>	4.1 (diesel) 5.6 (total <sup>5</sup> )	5.9 (diesel) 6.2 (total <sup>5</sup> )	<b>No</b>
Sulfur Dioxide (SO <sub>2</sub> )	12.1	12.8	<b>No</b>
Volatile Organic Compounds	12.8	13.5	<b>No</b>

(VOCs)			
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<sup>1</sup> Based on Emissions Provided by BNSF.

<sup>2</sup> Based on Emissions Provided by BNSF & Company Growth from 2005 to 2007.

<sup>3</sup> Total includes Windblown Dust

<sup>4</sup> Includes BNSF Line-haul & Switch Yard Emissions

<sup>5</sup> The remaining PM<sub>2.5</sub> is from dust generated at the railyard.

**Table 2 BNSF Railyard Toxic Air Pollutant Emissions (based on emissions factors)**

Toxic Pollutant of Concern	CAS No	Total 2005 Emissions ppy	Total Projected 2007 Emissions ppy	Do Projected 2007 Concentrations Exceed the ASIL? If so, by what factor?
1,3-Butadiene	106-99-0	48.2	51.1	<u>2.9</u>
Acetaldehyde	75-07-0	278.7	295.9	<u>NO</u>
Acrolein	107-02-8	46.2	49.1	<u>1.4</u>
Benzene	71-43-2	38.4	40.8	<u>NO</u>
Beryllium	7440-41-7	0.3	0.3	<u>NO</u>
Cadmium	7440-43-9	0.3	0.3	<u>NO</u>
Chromium	18540-29-9	0.1	0.1	<u>3.3</u>
Formaldehyde	50-00-0	641.9	681.4	<u>1.4</u>
Lead	7439-92-1	0.9	0.9	<u>NO</u>
<b>Subtotal Toxics</b>		<b>1,055</b>	<b>1,120</b>	

**Table 3 BNSF Railyard Toxic Air Pollutant Emissions (based on % PM<sub>10</sub>)**

Toxic Pollutants (% PM <sub>10</sub> )	CAS No	Total 2005 Emissions ppy	Total Projected 2007 Emissions ppy	Do Projected 2007 Concentrations** Exceed the ASIL? If so, by what factor?
Acenaphthene	83-32-9	0.4	0.4	<u>N/A</u>
Acenaphthylene	208-96-8	5.2	5.5	<u>N/A</u>
Anthracene	120-12-7	1.2	1.3	<u>N/A</u>
Benz[a]anthracene	56-55-3	0.2	0.2	<u>NO</u>
Benzo[a]pyrene	50-32-8	0.0	0.0	<u>NO</u>
Benzo[b]fluoranthene	205-99-2	0.1	0.1	<u>NO</u>
Benzo[g,h,i]perylene	191-24-2	0.0	0.0	<u>N/A</u>
Benzo[k]fluoranthene	207-08-9	0.1	0.1	<u>NO</u>
Chrysene	218-01-9	0.1	0.2	<u>NO</u>
Dibenzo[a,h]anthracene <sup>6</sup>	53-70-3	0.0	0.0	<u>NO</u>
Diesel Particulate Matter *	DPM	11,228.9	11,890.7	<u>1,190.2</u>
Fluoranthene	206-44-0	0.9	1.0	<u>N/A</u>
Fluorene	86-73-7	1.7	1.8	<u>N/A</u>
Indeno[1,2,3-c,d]pyrene	193-39-5	0.0	0.0	<u>NO</u>
Manganese	7439-96-5	0.0	0.0	<u>NO</u>
Naphthalene	91-20-3	31.5	33.4	<u>NO</u>
Nickel	7440-02-0	0.1	0.1	<u>NO</u>
Phenanthrene	85-01-8	6.9	7.3	<u>N/A</u>
Pyrene	129-00-0	1.3	1.4	<u>N/A</u>
<b>Subtotal Toxics</b>		<b>11,279</b>	<b>11,944</b>	

\* Based on PM<sub>2.5</sub>

\*\* The air pollutants with a N/A in the fourth column were included in the original 2005 emissions inventory submitted by BNSF to Ecology; however, means that this compound is no

longer a toxic in chapter 173-460 WAC; however, prior to May 2009 it was.

**Table 4 BNSF Railyard Toxic Air Pollutant Emissions (based on % VOCs)**

Toxic Pollutants (% VOCs)	CAS No	Total 2005 Emissions ppy	Total Projected 2007 Emissions ppy	Do Projected 2007** Concentrations Exceed the ASIL? If so, by what factor?
2,2,4-Trimethylpentane	540-84-1	57.4	60.7	<u>NO</u>
Ethyl Benzene	100-41-4	51.3	54.2	<u>NO</u>
Hexane	110-54-3	141.1	149.0	<u>NO</u>
Propionaldehyde	123-38-6	156.4	165.2	<u>NO</u>
Styrene	100-42-5	53.9	56.9	<u>NO</u>
Toluene	108-88-3	82.1	86.7	<u>NO</u>
Xylenes	1330-20-7	123.1	130.0	<u>NO</u>
<b>Subtotal Toxics</b>		<b>665</b>	<b>703</b>	
<b>Total Toxics</b>		<b>3,596</b>	<b>3,911</b>	
<b>Total HAPs</b>		<b>12,981</b>	<b>13,747</b>	
<b>Maximum Single HAP</b>		<b>11,229</b>	<b>11,891</b>	

<sup>3</sup> Line haul emissions are for all of Spokane County

<sup>4</sup> Emissions are exclusively for the railyards

<sup>5</sup> Amtrak emissions are for all of Spokane County

<sup>6</sup> Emission factor based on AP-42 w/ units of lbs pollutant/MMBtus Heat Input

The last column of each table denotes the ratio of the maximum concentrations to either the NAAQS or the ASIL. Numbers in red indicate an exceedance of either the NAAQS or the ASIL, whichever is applicable. As can be seen in Table 1, NOx emissions are large and modeling predicts downwind ambient air quality to exceed the NOx NAAQS by a factor of 1.52.

In addition, Table 2 shows that four toxic compounds; 1,3-Butadiene, Acrolein, Chromium VI, and Formaldehyde exceed their ASILs by a factor of 2.9, 1.4, 3.3, and 1.4, respectively. Except for Diesel Particulate Matter (DPM), the other toxic compounds in Tables 3 and 4 were well under their individual ASILs. With the revision to chapter 173-460 WAC in May, 2009, some of the toxics were eliminated from the new WAC 173-460-150 list; therefore, those toxics show N/A in the "Maximum concentration to ASIL" column.

Although DPM is not a criteria pollutant in and of itself, it is a component of PM and especially makes up a majority of the emissions of PM<sub>2.5</sub> shown above. DPM, at the time of this report, does not have a federal air quality standard; however, as stated previously DPM is extremely toxic and many of the TAP emissions shown above are a component of DPM.

Ecology recently added DPM to its list of toxic compounds. SRCAA decided to evaluate the DPM as it did the other toxic compounds. The results show that DPM's maximum concentration exceeded Ecology's listed ASIL by a factor 1190 times the ASIL. Since SRCAA used a screening model, results tend to be conservative estimates. The DPM ASIL exceedance factor above should not be interpreted to be representative of an actual exceedance factor. It is only an indicator that DPM emissions from the BNSF railyard appear to be much more of a cancer health risk to the surrounding population than the other toxic air pollutants shown in Table 2-4.

A more sophisticated model and actual source test information from the line haul and switching equipment would most likely result in a lower emission factor and DPM concentration levels. Even so, SRCAA believes that the DPM concentration levels would still be relatively high using

the refined modeling methods & source test emission factors because it is not likely that the refined model results would reduce the pollutant's concentration below the ASIL.

### **Non-road locomotive engines**

The above section approximates emissions and concentration levels based on an assumption that the locomotives and switching engines at the BNSF railyard are new sources. However, EPA regulates nonroad engines differently than new stationary sources. Nonroad engines cannot be required to go through new source review and thus are not required to get an order of approval from SRCAA.

SRCAA only made the above assumption as a way to provide the public with an idea of the possible magnitude of various criteria and toxic air pollutant emissions and concentrations and to relate to the public possible health impact of the BNSF railyard on its surrounding population,

## **X.EPA CONTROL OF EMISSIONS FROM NONROAD LOCOMOTIVE ENGINES**

The EPA has implemented rules to control emissions from locomotive engines and thus decrease emissions and health impacts to the population at large. The following are a number of ways EPA, intends to do address, or is already implementing the emission reductions and accompanying health impacts.

### **A. Clean Air Nonroad Diesel Rule**

The Clean Air Nonroad Diesel Rule, EPA finalized new requirements for nonroad diesel fuel that will decrease the allowable levels of sulfur in fuel used in locomotives by 99 percent. The requirement for locomotives to burn ultra-low sulfur diesel (ULSD) takes effect in 2012. This requirement will lower the emissions of sulfur compounds which are a component of DPM. The fuel improvements are expected to create immediate and significant environmental and public health benefits by reducing DPM from existing locomotive engines.

### **B. Stringent Locomotive Emissions Standards**

The EPA has adopted standards intended to reduce DPM and nitrogen oxide (NOx) emissions from locomotives. It is a three-part program aimed at:

1. Tightening emissions standards for existing locomotives and large marine diesel engines when they are remanufactured;
2. Setting near-term engine-out emissions standards, referred to as Tier 3 standards, for newly-built locomotives and marine diesel engines; and
3. Setting longer-term standards, referred to as Tier 4 standards, for newly-built locomotive diesel engines that reflect the application of high-efficiency control technology.

### **C. Control of Emissions from Idling Locomotives**

EPA passed new idle reduction requirements for newly-built and remanufactured locomotives and adopted provisions to encourage a new generation of clean switch locomotives, based on clean nonroad diesel engine standards. EPA estimates 90 % DPM reductions and 80 percent NOx reductions from Tier 4 engines meeting these standards, compared to engines Tier 2 standards.

## **XI. SPOKANE BNSF RAILYARD APPROXIMATED DPM CANCER RISK STUDY**

It is not the goal of this study to do an in-depth analysis of the effect of the Spokane BNSF railyard on cancer risk. As stated before, the ARB risk assessments required approximately 75 full-time employees, around 3 – 4 months, and significant funding to complete. SRCAA's resources and expertise are extremely limited for performing a risk assessment equivalent to the in-depth analysis performed by ARB on the Spokane BNSF railyard. Instead SRCAA is attempting to establish, using an ARB study from a California railyard similar to the Spokane BNSF railyard to approximate the DPM cancer risk to the area surrounding the railyard.

### **Non-cancer Health Risk**

ARB found that the potential non-cancer health hazard index from diesel PM emissions from the UP Stockton Railyard are estimated to be less than 0.1. If a non-cancer health hazard index exceeds one, people are exposed to levels of chemicals that may pose non-cancer health risks. To attain an ample margin of safety to protect public health, a chemical's hazard index should be substantially below one. As a result of ARB's finding concerning the non-cancer health hazard index being low, ARB did not address non-cancer risk in their study. SRCAA did not address the non-cancer health hazard index in this report either.

### **DPM Cancer Health Risk**

Because Stockton, CA and Spokane, WA have numerous similarities listed previously, SRCAA believes that it is not unreasonable to take the Stockton study to approximate the DPM cancer risk that the Spokane BNSF railyard may have on the population surrounding it. The approximation takes into consideration the differences due to railyard shape and orientation, and the difference in the prevailing wind directions and wind speeds.

The prevailing wind direction for the Stockton area is northwesterly (wind direction from NW to SE). Based on Felts Field information, 95% of the time the prevailing wind direction in the area around Spokane's BNSF railyard is southwesterly (wind direction from SW to NE) and has a 50-year average of 8.9<sup>12</sup> miles per hour.

Figure 3 shows a one mile radius (black circle) around the BNSF railyard and the residential areas (orange) that fall within that radius. They are mostly located to the north or northwest of the railyard.



**Figure 3 Residential areas within one mile radius of the BNSF railyard.**

Adjusting for the prevailing wind direction differential and the railyard orientation differential between Stockton and Spokane, Figure 4 hypothesizes what overlaying the isopleths from the Stockton study over the Spokane's BNSF railyard could resemble. The 100 and 50 isopleths were oriented with respect to BNSF's railyard and it is expected that a more accurate case for the BNSF railyard would have these isopleths following the railyard's shape; however, SRCAA believes that what is shown roughly approximates the BNSF's isopleths.

SRCAA believes that the 25 & 10 isopleths would be fairly close to actual, except that because the average wind speed for the Spokane area is slightly higher, one might expect that these two isopleths could be pushed toward the northeast a little more than what is shown in Figure 4, but not significantly.

<sup>12</sup> <http://www.ncdc.noaa.gov/oa/climate/online/ccd/avgwind.html> (8/31/2011)

## **Residences and People that reside within the 1-mile and 2-mile radius around the BNSF Railyard**

Based on Figures 3 & 4, we see that there is a residential area approximately 900 feet to the north of the railyard. There are approximately 150 residences in this area with a possible population of 500 – 600. This population resides within the 50 to 100 per million risk zone.

Spokane County GIS estimates that 1050 residences or approximately 3150 people reside within the 1-mile radius (black circle in Figure 3) around the BNSF railyard's emissions centroid. This circle approximates the 25 per million risk zone. Deducting the residences immediately to the north of the BNSF railyard, this leaves 900 residences or approximately 2,600 people that reside within the 25 to 50 per million risk zone.

Significantly more residences are within the 2-mile radius (white circle in Figure 4) around the emissions centroid of the BNSF railyard and they border on all sides of the railyard. The Spokane County GIS system estimates 7500 residences or approximately 22,000 people reside within a two-mile radius of the BNSF railyard. The two-mile radius approximates the 10 per million risk isopleth. When one deducts the 1050 residences within the 1-mile radius, it leaves approximately 6450 residences or approximately 18,700 people that reside within the 10 to 25 per million risk zone.

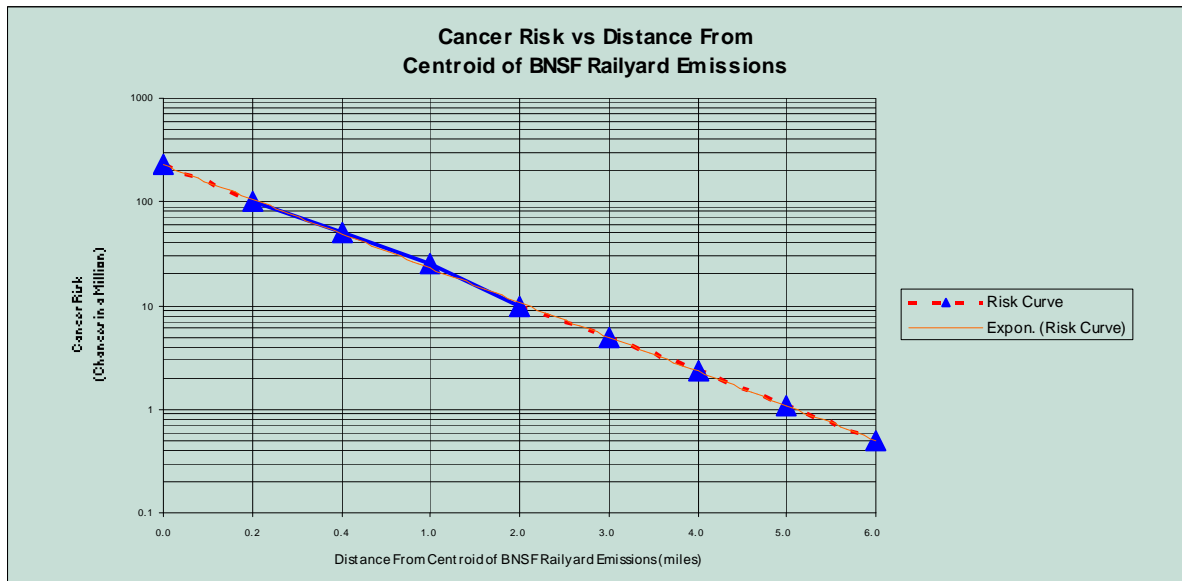


**Figure 4 Regional (1 and 2-mile radii) isopleths around the BNSF railyard**

## **Cancer Risk vs. Distance from BNSF.**

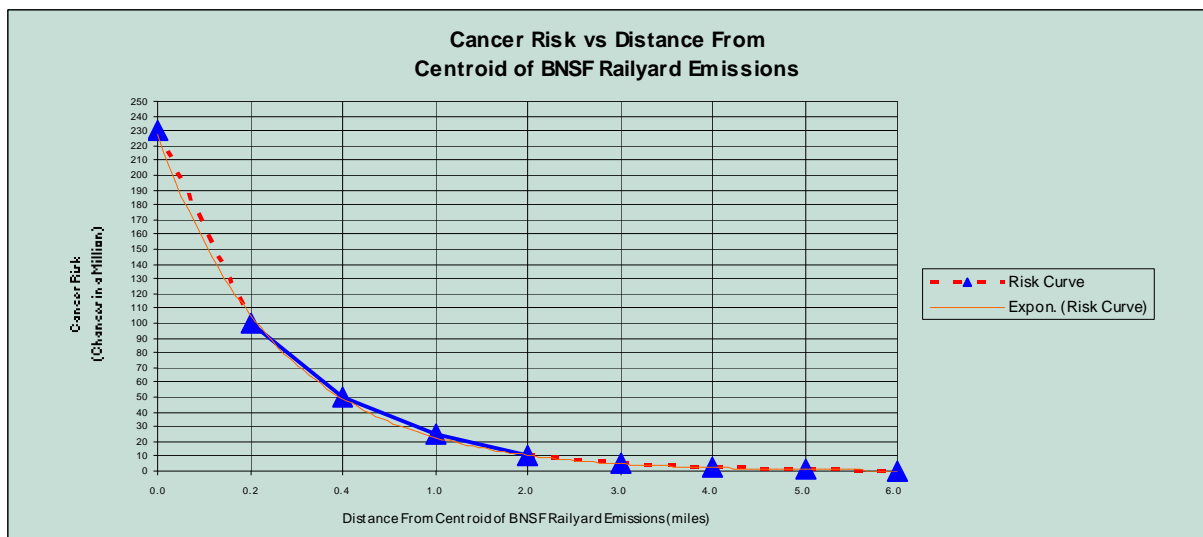
ARB did not evaluate the 1 per million risk isopleth; however, when one plots the known risk vs. distance on a log scale, the plot very closely approximates a straight line. Extending the line, which is equivalent to extending the radius from the BNSF railyard emissions centroid, extrapolates where the 1 per million risk radius might occur. Chart 1 indicates that at a radius of 3 miles one might see a 5 per million chance of cancer and extending further indicates that the 1 per million risk might occur at approximately the 5-mile radius. As indicated earlier, ARB and Ecology consider a modeled cancer risk of 1 in a hundred thousand (10 per million) to be an acceptable risk. Based on Figure 4 above and the charts below, an acceptable risk for cancer would occur just a little beyond the two mile radius from the BNSF railyard's emissions centroid.

The dark blue portion in the curves presented in the charts below represent approximated risk versus distance from the BNSF railyards emissions centroid, while the red dashed line represents the extrapolated data. The orange line represents the trend line of the curve.



**Chart 1 Logarithmic plot of risk vs. distance**

One would expect that the risk should decrease the further one gets away from the source, because the pollutant concentrations get lower the further from the source. Chart 2 is Chart 1 re-plotted on a normal scale. The plot reveals an exponential curve relating to risk vs. distance. It can be seen from the curve below that the 10 per million cancer risk occurs at an approximate distance of 2 miles from the BNSF railyards emissions centroid. The dark blue portion of the curve represents the hard data, while the red dashed line represents the extrapolated data. The orange line represents the trend line of the curve.



**Chart 2 Normal plot of risk vs. distance**

### **Spokane BNSF Railyard Risk Study Summary**

The risk study was done because of similarities between Spokane and Stockton. Assumptions were made to address the differences between the two locations, which means that an exact risk to populations surrounding BNSF cannot be assigned. However, it appears that there is the

possibility that a significant population could be exposed at a level exceeding the Washington Department of Ecology's acceptable cancer risk.

It should be noted that this study only addresses the emissions from the Spokane BNSF railyard and its impact upon residences in close proximity. There are numerous other sources within the area that also impact the health of the population. Although these have not been enumerated, ARB found that off-site diesel PM emissions constituted almost 59% of the total diesel PM emissions within a 1-mile radius of the Stockton UP railyard. Since Stockton and Spokane are similar as to the ratio of residential to industrial area surrounding the railyards, it would not be unreasonable to assume that this would apply in the Spokane area as well.

The residents just to the north of the BNSF railyard, within less than 1000 feet from the emissions centroid of the BNSF's emissions production area, could be exposed at, or above, 50 and 100 per million risk of cancer due to the Spokane BNSF railyard operations. There are approximately 150 residences in this area with a possible population of 500 - 600, suggesting that over 70 years one could expect a significant number of occurrences of cancer in that residential area.

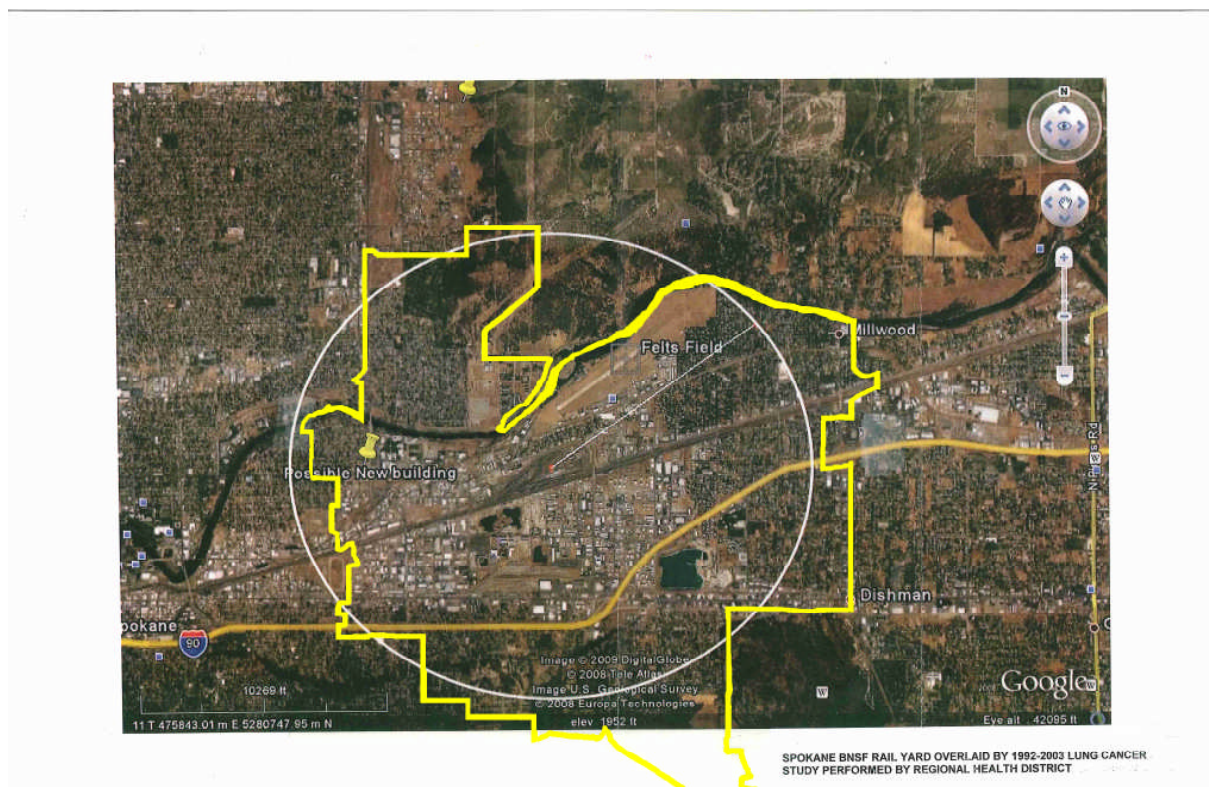
The residents to the northeast, northwest and south of the BNSF railyard could experience cancer risks between 10 and 25 per million risk. Hundreds of residences in west Millwood and to the northwest in Hillyard are in this area.

Based on extrapolation of the risk vs. distance data, one could see an elevated risk influence as far away as 5 miles to the east and west of the Spokane BNSF railyard, depending upon the wind direction. Charts 1 & 2 indicate that the 1 per million risk isopleth might occur around 5 miles away from the BNSF railyard. This of course is fairly speculative, as it assumes a flat contour throughout the 5 mile radius, which is not the case since the Spokane BNSF railyard is located in a valley and the contours to the north and south are foothills. Stockton lies in a flat plain almost at sea level and the plain is much more expansive than the plain where the Spokane BNSF railyard is located. However, closer in to the BNSF railyard (i.e. within 2 miles of) the Stockton results could be fairly representative of the risks around the Spokane railyard.

Since the population of the City of Spokane as of 2007 was 200,975. This study indicates that approximately 22,500 people (around 11% of the City of Spokane's population) may be exposed to at least a 5 chance per million risk of contracting cancer due to the emissions coming from the Spokane BNSF railyard.

## **XII. DEPARTMENT OF HEALTH LUNG CANCER CLUSTER STUDY (1992-2003)**

The Washington State Department of Health (DOH) studied the number of cases of lung cancer in the Spokane area around 2004. It covered the years 1992 to 2003. The results show that there were 260 cases of lung cancer in the study area in the eleven year period, averaging approximately 24 cases per year. Figure 5 shows the boundaries (in yellow) within which the lung cancer cases occurred. This area falls mostly within a 2 mile radius around BNSF's emissions centroid. It should be noted that this area corresponds quite well with the areas of the isopleths surrounding the BNSF railyard. The two mile radius approximately represents ARB's and Ecology's allowable cancer risk of 10 per million. This section shows a close relationship to DOH's area of concern in their study and the allowable 10 per million cancer risk distance in Section VI.



**Figure 5 Overlay of DOH Lung Cancer Study (1992-2003)**

### **XIII. DEPARTMENT OF HEALTH 2010 LUNG CANCER CLUSTER INVESTIGATION (1992-2006)<sup>13</sup>**

Based on the results of SRCAA's risk study, SRCAA's Director (Director) was concerned for the health of the public residing in the area within a two-mile radius of the Spokane BNSF railyard. In a letter date September, 29<sup>th</sup> 2009, the Director requested the Washington State Department of Health (DOH) to perform a lung cancer cluster assessment for the area and compare it to the City of Spokane's average occurrences and to perform any other study that the DOH considered to be appropriate.

In response to the Director's letter, the DOH initiated a 2010 cancer cluster investigation for the years 1992-2006 focusing on the cancers associated with diesel particulate matter (DPM). The two cancers that were investigated were lung and bladder cancers, because they are the primary cancers associate with exposure to DPM. They used a ratio of the observed number of cases of cancer to the expected (O/E) to compare the Washington State and the City of Spokane's O/E ratios to the Hillyard area in Spokane County for each of the cancers. If the O/E is greater than 1, then that indicates that there are more cancer victims than would be expected according to the State's expectation for the study area. The DOH considers an O/E greater than 1 to be "statistically significant". Conversely, if the O/E is 1 or less than there is not a significant risk expected.

The investigation indicated that the O/Es for bladder cancer were not statistically significant.

The cancer cluster investigation found that the population living in the Hillyard Area, which is adjacent to the BNSF railyard, showed a statistically significant O/E of 1.4 for lung cancer when the actual cases of lung cancer are compared with the Washington State's expected cases of lung cancer for the study area.

<sup>13</sup> Judy Bardin, ScD Epidemiologist, Letter to William Dameworth Concerning a Cancer Cluster Investigation of the Hillyard Region in the City Spokane, (Olympia, WA: Wahington State Department of Health, January 22, 2010) 5.

While the DOH considers the O/E for lung cancer in the population living near the BNSF rail yard to be elevated and statistically significant compared to the reference population of the state, they believe that it is not sufficiently so to warrant a public health investigation. Based on the DOH's cluster guideline criteria, the O/E needs to be least 2.0 when there are 50 or more people with the same type of cancer to investigate further.

The Hillyard Region (Hillyard) is outlined in red in the Figure 6 below. The BNSF railway is outlined in green.

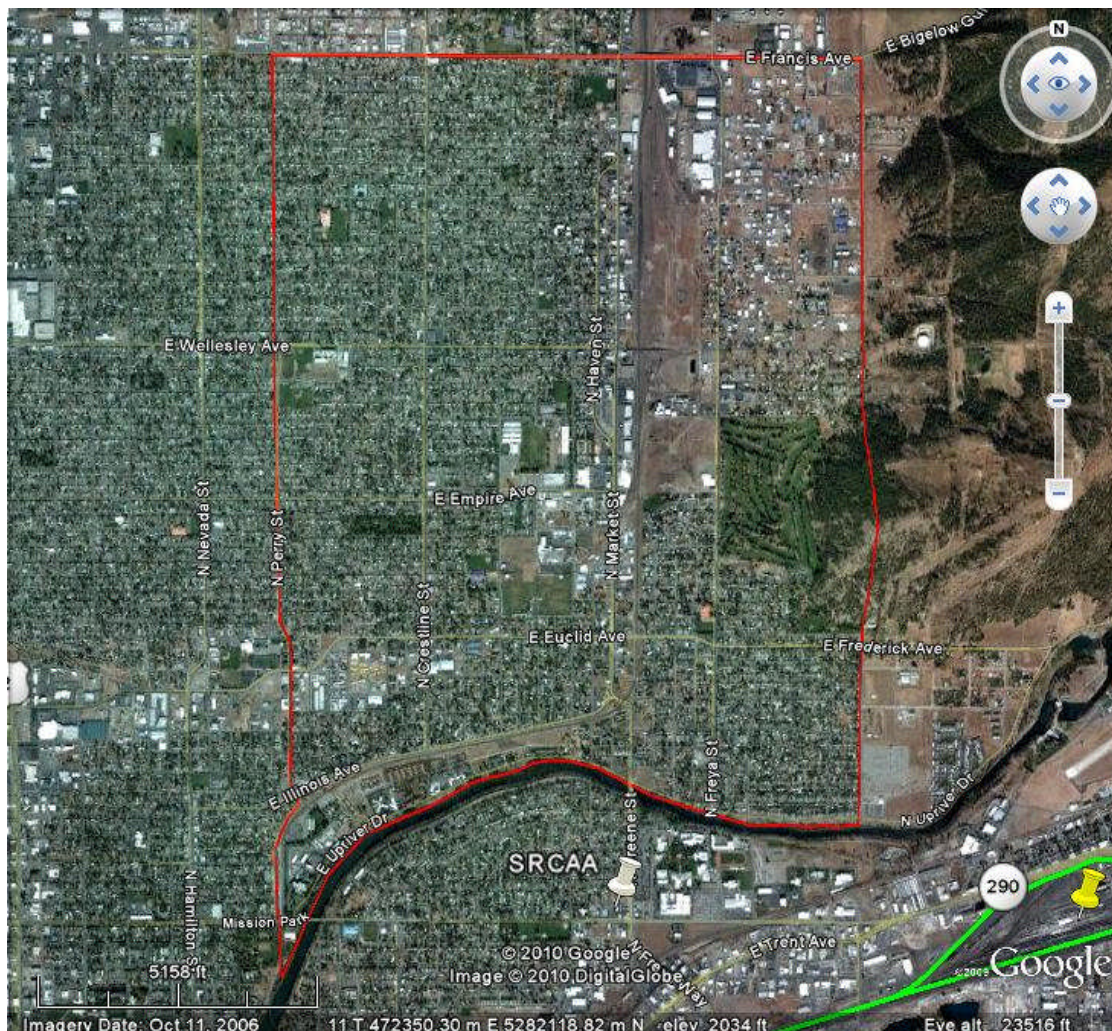


Figure 6 Hillyard Suburb Area

### Elimination of Factors that Hillyard Contribute to or Cause Lung Cancer differential

DOH's cancer cluster report lists various factors that could affect the O/E for lung cancer. The factors include cigarette smoking, radon, vehicular traffic, a regional airport, and industrial sources, including some industrial sources that are either no longer in existence or are very insignificant emitters of air pollutants.

There is no doubt that these kinds of factors affect the occurrence of lung cancer. **However it is important to understand that the focus of the O/E is the fact that the risk is higher for the Hillyard area relative to the State and the Spokane City/County metroplex. Therefore we are looking for factors that would differentiate the Hillyard area from the State and the Spokane City/County metroplex.**

Few, if any, of the sources in close proximity to Hillyard would generate emissions of diesel PM<sub>2.5</sub> or toxic air pollutants. There are very few toxic air pollutant sources in the immediate

area of Hillyard, except for some gas stations and a few auto body shops. These are all minor sources with annual emissions on the order of 200 lbs of VOCs (most of which are toxic emissions) and have minimal impact on the Hillyard area.<sup>14</sup>

### **Cigarette smoking**

SRCAA would expect that the risk due to smoking would be fairly consistent for all urban areas in the State. Therefore, the risk due to smoking, although it contributes to the risk of lung cancer, would not likely contribute to the differential risk between Hillyard, the State, and the Spokane City/County metroplex. That is, there is no available evidence that people living in Hillyard smoke any more than any other urban area of the State or the Spokane City/County metroplex.

### **Radon**

At this time, to SRCAA's Knowledge, there is no indication that the Hillyard area's radon levels are any different than any other part of Spokane County. EPA has classified all of Spokane County as Zone 1 for radon. According to EPA, this means all of Spokane County is counted as one of the areas with the highest level of average radon concentrations present in homes. Therefore, radon levels would not likely contribute to the differential risk between Hillyard and the Spokane City/County metroplex as well.

The Spokane Regional Health District (SRHD) tracked radon levels in Spokane County during the 1990's using radon kits and constructed a map showing Spokane County radon levels. However, according to the SRHD, the results were inconsistent. SRHD found that residences within the same community, even residences built the same year, of the same construction type, located on the same geological base, and that were even adjacent to each other, varied widely in radon exposure levels. SRHD has disposed of the Spokane County radon map and is no longer pursuing radon monitoring.

### **Vehicular Traffic**

The report states that two major roadways may affect the occurrence of lung cancer, those roadways being Trent Avenue and Interstate 90 (I-90). It is SRCAA's opinion that the traffic on I-90 would have little impact on the Hillyard area as I-90 is 3 ½ miles away.

According to the City of Spokane's latest Traffic Flow Map (2006-2007), the vehicular traffic along Trent Avenue in the area close to Hillyard amounts to ≈25,000 vehicles per day. Approximately the same amount of traffic passes through Hillyard each day. The City of Spokane estimates that trucks amount to ≈5% of that traffic. Therefore, ≈ 1250 trucks a day travel the area close to or through Hillyard. SRCAA assumes that all of the trucks combust diesel; however, not all trucks do.

As far as N-S vehicle traffic is concerned, SRCAA has reviewed the City of Spokane's 2007 traffic count and observed that the amount of traffic traveling through Hillyard is actually less than most of Spokane's N-S arterials. Presently, north/south truck traffic in Spokane is restricted for the most part to the Monroe St., Greene/Haven/Market, Nevada St., and the Division/Ruby St. corridors. The vehicular traffic on Monroe St. and Nevada St. is approximately the same as the Greene/Haven/Market St. corridor; whereas, the traffic on the Division/Ruby St. corridor is twice the amount on the Greene/Haven/Market St. corridor.

A North/South freeway, presently being built, bypasses downtown Hillyard to the east. SRCAA expects that once it is finished the truck traffic on the Greene/Haven/Market St. corridor would lessen significantly thus lowering truck traffic's contribution to lung cancer risk in Hillyard.

Trent Ave. is oriented east/west and borders many neighborhoods. Traffic increases as it moves further west into the Spokane City center; therefore, we would expect that the cancer risk due to truck traffic in other neighborhoods closer into the Spokane City Center would be greater than in Hillyard.

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<sup>14</sup> SRCAA 2005 Toxic Emissions Inventory Study

Whereas toxic emissions, with the exception of diesel PM<sub>2.5</sub> emissions, generated by normal traffic do contribute to the lung cancer risk, the resulting toxic emissions related to normal traffic would likely be the same or less than other equivalent areas of Spokane with N-S arterials and would not likely contribute to the differential risk between Hillyard and the Spokane City/County metroplex either.

SRCAA agrees that the truck traffic diesel PM<sub>2.5</sub> emissions contribute to the cancer risk; however, because the level of truck traffic increases on the arterials as one travels into the City of Spokane along Trent, it is logical that the DPM cancer risk associated with truck traffic would increase as well. So truck traffic, in and of itself, would not seem to affect the risk differential adversely between Hillyard and the rest of Spokane. In fact, it may be the reverse, as the risk due to truck traffic would logically expect to increase along truck traffic arterials with heavier traffic.

### **Regional Airports**

Felts Field is inside of the review area; however, it is not a regional airport and diesel PM<sub>2.5</sub> emissions would be minimal, probably non-existent, since the fuel used at that airport is aviation gasoline. Aviation gasoline combustion does not produce diesel PM<sub>2.5</sub> emissions. The traffic from Felts field is extremely light and is generally for private aircraft use; therefore toxic emissions would also be minimal. The Deer Park Airport is comparable in size and aircraft traffic to Felts Field and, because of low aviation gasoline usage, is exempt from registering with SRCAA as an air pollution source. That means that the emissions of all pollutants are too low to be reportable. We would expect that due to the similarities between Deer Park Airport and Felts Field, Felts Field would have minimal impact.

Spokane International Airport (SIA) is ≈ 10 miles away.) SIA's impact on differential risk would be minimal, most likely non-existent because of the distance to Hillyard.

### **Industry**

There is light industry relatively close to Hillyard (i.e. to the south); however, the businesses themselves are not sources of the diesel PM<sub>2.5</sub> and are minimal sources of toxic pollutants as determined in a toxic emissions inventory performed by SRCAA in 2005.

The Spokane Industrial Park (SIP) is the largest of Spokane's heavy industrial parks and is ≈ 8 ½ miles away from Hillyard. To SRCAA's knowledge, there are no air pollution sources adjacent to, or inside of, the SIP that combust diesel. Generally, emissions from these sources include toxic pollutants; however, diesel PM<sub>2.5</sub> would be non-existent from these sources. All these sources are between 7 and 8 ½ miles from Hillyard. Toxic emissions from these sources would minimally impact Hillyard. Prevailing winds are southwesterly (i.e. blow to the northeast) and would carry toxic emissions generated in the SIP away from the Hillyard area.

### **BNSF Railyard**

The nonroad engine portion of the BNSF railyard is not a stationary source. However, emissions from the railyard tend to stay around the area longer because prevailing southwesterly wind speeds on average (≈ 9 mph) are low and foothills geography to the north tends to trap pollutants in the immediate BNSF railyard area. Trains and switching units emit high levels of diesel PM<sub>2.5</sub> and combined with frequent autumn/winter inversions in the area could result in higher concentrations of pollutants in the area.

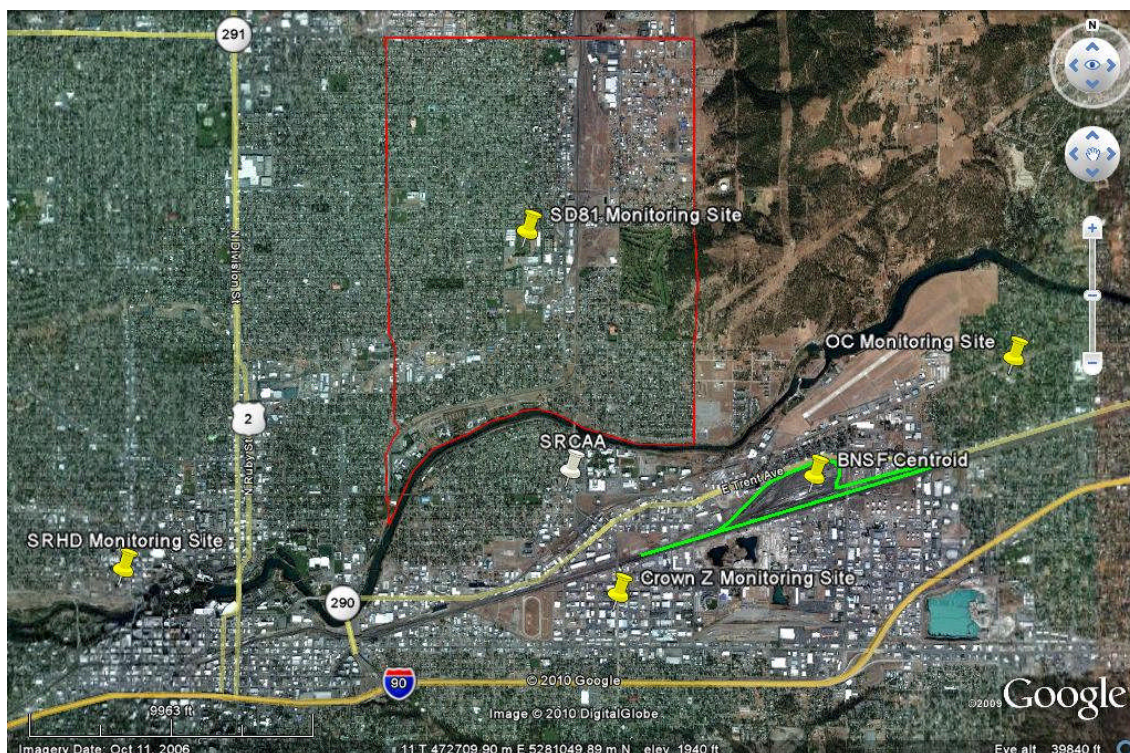
ARB's studies concentrated on the exhaust from the large UP rail yard and excluded other sources because they felt that other sources contributed minimally to the diesel PM<sub>2.5</sub> lung cancer risk, just as they asserted that Stockton's small railyard (BNSF) DPM cancer risk impact would be minimal when compared to the emissions from Stockton's UP railyard. BNSF is Spokane's large railyard and UP is Spokane's small one.

### **Section Summary**

As can be seen in this section, smoking, radon exposure, vehicular traffic (especially trucks that run on diesel), regional airports, and industry would not be expected to account for the differential cancer risk in Hillyard. The only air pollution source that is not common to the State, Spokane City/County metroplex and other neighborhoods is the BNSF railyard. The BNSF railyard appears to be the only other air pollution source in the vicinity of Hillyard that can account for the differential lung cancer risk between the Hillyard area, the State of Washington, and City of Spokane/County metroplex.

#### **XIV. TOXIC MONITORING STUDY (2005)**

In 2005, SRCAA conducted a toxic monitoring study within the Spokane City/County Multiplex where levels of 24 toxics were monitored at 4 monitoring sites. One site was located inside of the Hillyard area at the Spokane School District's Maintenance Facility (SD) 2.5 miles to the northwest of BNSF, one in the commercial/industrial area 1.5 miles to the southwest of BNSF, referred to as Crown Z (CZ), and another in the Millwood area at the Orchard Center Elementary School (OC) 1.5 miles to the Northeast of BNSF. The last monitoring site was located in an urban area setting at the Spokane Regional Health District (SRHD) which is located 4.6 miles to the Southwest of BNSF. SRCAA expects that due to the distance, the BNSF railyard would have an insignificant impact on the SRHD monitoring site. However, since the BNSF railyard is relatively close to the first three monitoring sites SRCAA believes that it does influence the toxic concentrations measured at those locations. Figure 7 below shows the locations of each of the monitoring sites relative to the BNSF railyard.



**Figure 7 Toxic Monitoring Sites Relative to the BNSF Railyard**

Ten of the toxic pollutants monitored are tracer pollutants associated with diesel combustion. Although it is difficult to assess what portion of the ten tracer pollutants that were measured can be allotted to the BNSF railyard, the relative concentrations of those toxic pollutants can be compared with those at the SRHD monitoring site. The ten toxic pollutants due to diesel combustion measured at the Spokane monitoring sites include the following:

##### Gases

- 1,3-butadiene
- Acetaldehyde

- Benzene
- Ethylbenzene
- Formaldehyde

#### Metals

- Arsenic (As)
- Beryllium (Be)
- Cadmium (Cd)
- Chromium (III) (Cr3) (i.e. trivalent chromium)
- Manganese (Mn)

Because the area surrounding SRHD is mostly urban residential development, its monitoring results can be used as toxic background emission levels for comparison with the other monitoring sites. The ratios of median concentrations for the other monitoring sites are compared to those at SRHD. The median concentrations are used because over the year of monitoring there was a wide variation for some of the toxics that were measured and the median is a better indicator of the result than using the average of the emission concentrations.

The other three monitoring sites tend to have median toxic concentrations that run higher than SRHD. Gases at CZ, OC, and SD, for example, tend to be between 7 – 66% higher than levels at SRHD, while metals run between 1 – 220% higher as shown in Table 5 below.

**Table 5 Percent increase of monitored toxic emission between SRHD and other monitoring sites**

		Other Monitoring Site Medians to SRHD Median Increase		
CAS	Pollutant	CZ	OC	SD
Gases				
106-99-0	1,3-butadiene	156%	107%	123%
75-07-0	Acetaldehyde	109%	137%	114%
71-43-2	Benzene	140% *	143%	163%
100-41-4	Ethylbenzene	163% *	121%	150%
50-00-0	Formaldehyde	126%	166%	163%
Metals				
7440-38-2	Arsenic	191%	133%	118%
7440-41-7	Beryllium	133%	122%	168%
7440-43-9	Cadmium	141%	138%	130%
7440-47-3	Chromium	319% *	104%	80%
7439-96-5	Manganese	304% *	105%	96%

\* Because there are other sources of these air pollutants in close proximity to the CZ monitor, these numbers are unreliable.

Trivalent chromium and Mn are also tracer pollutants associated with welding operations; therefore, CZ's Cr<sub>3</sub> and Mn numbers are most likely higher than the other two sites because there is a welding facility across the street from CZ which makes the Cr<sub>3</sub> and Mn ratios unreliable.

In addition, benzene and ethylbenzene are also products of combustion from other types of fossil fuels and are also emitted from gasoline dispensing facilities and storage tanks which are in the area surrounding BNSF railyard. Thus, the benzene and ethylbenzene ratios are not reliable either.

However, the presence of the gases 1,3-butadiene, acetaldehyde, and formaldehyde and the metals arsenic, beryllium, and cadmium are characteristic markers of diesel combustion; thus, the percent increase for those pollutants are of interest. Using the factor that ARB used in their analysis of 59% of the PM<sub>2.5</sub> emissions resulting from the off-site operations, then gases of interest (in bold) generated at CZ, OC, and SD could be between 3 – 27% higher than levels at

SRHD, while metals of interest (in bold) could range between 7 – 37% higher as shown in Table 6 below.

**Table 6 Percent increase of monitored toxic emissions between SRHD and other monitoring sites assuming 41% is allotted to BNSF railyard**

		Assuming that 41% can be allotted to the railyard.		
CAS	Pollutant	CZ	OC	SD
<b>Gases</b>				
106-99-0	<b>1,3-butadiene</b>	<b>123%</b>	<b>103%</b>	<b>110%</b>
75-07-0	<b>Acetaldehyde</b>	<b>104%</b>	<b>115%</b>	<b>106%</b>
71-43-2	Benzene	116% *	118%	126%
100-41-4	Ethylbenzene	126% *	108%	121%
50-00-0	<b>Formaldehyde</b>	<b>111%</b>	<b>127%</b>	<b>126%</b>
<b>Metals</b>				
7440-38-2	<b>Arsenic</b>	<b>137%</b>	<b>114%</b>	<b>107%</b>
7440-41-7	<b>Beryllium</b>	<b>114%</b>	<b>109%</b>	<b>128%</b>
7440-43-9	<b>Cadmium</b>	<b>117%</b>	<b>116%</b>	<b>112%</b>
7440-47-3	Chromium (III)	190% *	102%	92%
7439-96-5	Manganese	184% *	102%	98%

\* Because there are other sources of these air pollutants in close proximity to the CZ monitor, these numbers are unreliable.

The ARB HRA allocated 41% of the DPM to the Stockton UP railyard. Because of the similarities between Stockton's UP and Spokane's BNSF railyards, SRCAA is assuming that 41% of the increase in toxic emissions noted in Table 5 could be allocated to the BNSF railyard, as represented in Table 6. Table 6 indicates that the BNSF railyard would appear to be a significant air toxics contributor to the CZ, OC, and SD recorded monitoring site toxic emissions.

### **Section Summary**

Summarizing, in the areas around the BNSF railyard the 2005 toxic monitoring study's toxic emissions impacts apportioned to BNSF's railyard operations appear to account for between 3 – 23% of the 1,3-butadiene (Avg. 12%), 4 – 15% of the acetaldehyde (Avg. 8%), and 11 – 27 % of the formaldehyde (Avg. 21%) gases and for metals, 7 – 37% of the arsenic (Avg. 19%), 9 – 28 % of the beryllium (Avg. 17%), and 12 – 17% of the cadmium (Avg. 15%). All of the toxic pollutants referenced above are tracer pollutants associated with diesel combustion and are typical of emissions generated at the BNSF's railyard. This implies that the BNSF railyard could be a significant contributor to DPM cancer risk to the areas within two miles of the BNSF railyard, including the Hillyard area.

## **XV. WHAT ACTIVITIES COULD REDUCE DIESEL PM EMISSIONS AND PUBLIC HEALTH RISKS?**

### **A. Possible Regulatory Tools for reducing DPM emissions from the BNSF Railyard**

Washington State regulations do not offer a direct opportunity to regulate DP emissions from locomotives or railyards. However, at the time of this report, SRCAA is in the process of drafting a regulation for indirect sources, referred to as the "Indirect Source Rule (ISR)".

Indirect sources are defined as: any facility, building, structure, or installation, or combination thereof, which generates or attracts mobile sources that results in emissions of any air contaminant or toxic air contaminant. The definition of indirect source does not include construction sites that generate mobile source emissions for less than one year or facilities that are solely comprised of public roadways (e.g., freeways are not considered indirect sources under this rule). Indirect sources could potentially include warehouses, industrial parks, rail yards, transportation centers, airports, truck stops, etc.

However, the ISR has not been approved yet. A public hearing was held on August 4, 2011. The Board elected to defer its decision for six months in order to review additional public comments provided and gather more information before further consideration of the ISR.

**B. Partnering between the Burlington Northern/Santa Fe Railroad and Spokane Regional Clean Air Agency**

This involves working with BNSF to evaluate ways to obtain funding to reduce emissions from the BNSF railyard using different existing technologies to either alter or replace existing equipment within the railyard to reduce railyard emissions. Because of increased fuel costs, now may be the time to obtain possible government funding and BNSF capital to accomplish the goal of decreasing emissions and making the alterations or replacements which are economically and environmentally beneficial.

Possible positive outcomes for BNSF, depending upon technologies or railyard operational management changes made, include:

- Increased positive community image
- Decreased maintenance requirements and costs,
- Decreased on-site staff exposure to toxic pollutants,
- Improved on-site employee health costs due to reduced diesel combustion emissions, thus reduced medical leave use,
- Decreased fuel usage, thus decreased fuel related costs,
- Increased operational efficiency with the replacement old inefficient equipment,
- Possible decreased legal liability.

**C. Participating in the West Coast Diesel Collaborative (Collaborative)**

One of the primary ways to obtain funding for reducing emissions and health risks involves participating in the Collaborative. The Collaborative may be aware of sources of funding to help accomplish diesel emission reduction projects.

The Collaborative is a partnership between leaders from federal, state, and local government, the private sector, and environmental groups committed to reducing diesel emissions along the West Coast. SRCAA is a member of the Collaborative listed under "Public Agencies". BNSF and UP are members as well.

The Collaborative is focused on creating, supporting and implementing diesel emissions reductions projects. To accomplish this goal, the Collaborative:

- Raises awareness of the need for diesel emissions reductions and the many highly successful state, tribal, local, and regional efforts that promote and support voluntary projects;
- Creates a forum for information sharing among diesel emissions reductions advocates, and works to leverage significant new resources to expand voluntary diesel emissions mitigation efforts; and
- Implements projects that are regional in scope, leverages funds from a variety of sources, achieves measurable emissions reductions, and creates momentum for future diesel emissions mitigation efforts.

**D. Technologies and methods to reduce emissions**

The United States railroad companies are either presently involved in using or testing various plans and technological developments concerning switchers and/or line haul locomotives. With the increased costs associated with fossil fuel dependence and its future availability being so unreliable, the railroad companies are seriously investigating alternative methods to lower maintenance and fuel costs. Lowering fuel use results in lower diesel combustion emissions.

The following are some of the methods and technologies that railroad companies are employing to reduce diesel emissions and fuel usage.

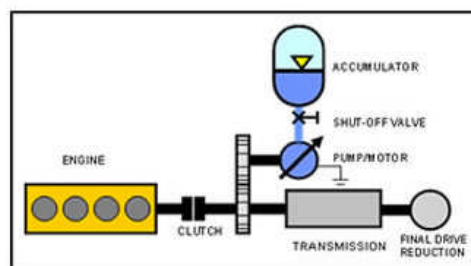
### 1. **Reduced Locomotive Idling**

Railroads have developed comprehensive plans to reduce the amount of time locomotive engines idle. Some of the plans involve using automatic stop-start equipment on newer locomotives to eliminate unnecessary idling. Older locomotives are being retrofitted with similar technology.

### 2. **Shore Power**

Long haul locomotives routinely carry large containers that have diesel-engine-driven trailer refrigeration units (TRUs) for keeping fresh and frozen foods cool in over-the-road transport. Railcars are often removed from trains and stored at railyards until the TRUs can be transferred to local or over-the-road trucks and trailers. However, the diesel engines that power these units create noise and air pollution while the units are running on diesel power.

As an alternative to using a diesel engine full-time, an electric powered trailer refrigeration unit (eTRU), as depicted in Figure 8, can be powered by either an on-board diesel generator or a shore power grid connection which would keep the refrigeration units cold. The railyard could install shore power electric grid systems to allow the eTRUs to be plugged in while being stored at the railyard. While these units are connected to shore power, diesel usage is eliminated completely thereby reducing fuel costs and the related diesel emissions.



**Figure 8 Electric powered trailer refrigeration unit**

In addition, ancillary equipment powered by internal combustion engines could be replaced with electric powered equipment (e.g. forklifts, trucks, etc.) thus further reducing emissions coming from the railyard and saving on fuel use.

### 3. **New Switcher Technologies**

Numerous railroad companies have been testing and is using various technologies to reduce air pollutant emissions and to conserve fuel.

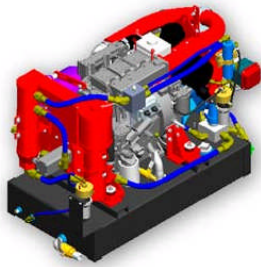
NOTE: Many of the following technologies are used by other railroad companies; however, the ones shown here show UP's versions of what is available:

- Diesel Driven Heating System (DDHS)
- Diesel Particulate Filters (DPF)
- Oxicat
- The Genset Switcher (GS)
- Hybrid Switchers and Line Haul Locomotives
- Advanced Locomotive Emissions Control System (ALECS)

#### **a. Diesel Driven Heating System (DDHS)**

Between Feb 2004 and May 2005, Southwest Clean Air Agency, (SWCAA) in conjunction with partners: BNSF, Kim Hotstart Manufacturing Company (manufacturer of diesel driven heating systems), and ZTR Control Systems (manufacturer of automatic shut-down/start up technology), received an EPA grant to evaluate the effectiveness of idle reduction technology on locomotive switchyard engines in Vancouver, WA.

BNSF installed DDHSs (Figure 9) and a ZTR automatic shut-down/start up technology (Figure 10) on three of their diesel switcher locomotives (switchers) in the BNSF's Vancouver railyard. The three switchers were originally built between 1964 and 1978. During the project, these switchers operated for 1 year during which SWCAA gathered data that measured reduced idle time and fuel savings.



**Figure 9 Kim Hotstart Diesel Driven Heating System**



**Figure 10 ZTR Control Systems SmartStart System**

The project resulted in:

Reduction of idle time (8700+ hours);

Reduction in diesel usage (approximately 48,000 gallons of diesel);

Reduction of total criteria pollutant emissions by 15.4 tons/yr.

SRCAA believes that this technology could readily be applied to switchers at the Spokane BNSF railyard and would reduce criteria and toxic pollutant emissions from BNSF's railyard, as well as the cancer risk to the surrounding commercial, industrial, and residential areas.

#### **b. Diesel Particulate Filters (DPF)**

The DPF (Figure 11) uses high-temperature silicon carbide blocks to trap particulate matter in the exhaust. As gases containing the carbon particles accumulate, the device periodically heats the carbon, causing it to ignite and burn off as carbon dioxide. Particulate emissions are reduced by 75%.



**Figure 11 The rail industry's first experimental exhaust filter (gray box on top engine cover) (Photo Courtesy Union Pacific)**

### **c. The Oxicat**

The Oxicat (Figure 12) is an emission-reduction device for older switchers and long haul locomotives that are equipped with a set of oxidation catalysts or "Oxicat" converter devices. As the diesel engine's exhaust flows through these converters, particulate matter generated by the diesel combustion process will be converted into water and carbon dioxide. The Oxicat operates much like a catalytic converter on today's cars and trucks. It is installed inside the diesel engine's exhaust manifold to reduce emissions.

This technology has the potential to reduce particulate emissions by about 50 percent, hydrocarbons by 38 percent and carbon monoxide by 82 percent.



**Figure 12 Oxicat Technology**

### **d. The Genset Switcher**

Genset switchers (Figure 13) are equipped with multiple gensets of varying horsepower, depending upon the manufacturer and/or a railyard's needs. At low throttle settings, only one of the ultra-low emissions diesel engines operates while the others are shut down. When additional power is needed, the other diesel engines automatically start and quickly go on-line producing the amount of electrical power required to move rail cars. The gensets provide electricity to multiple electric traction motors that turn axles to which the wheels are attached. The engines are equipped with auto shut-off controls when the switcher is not in use.

The pictured genset switcher is a UP Genset locomotive powered by three 700-horsepower low-emissions U.S. Environmental Protection Agency (EPA) non-road Tier 3-certified diesel engines. This Genset switcher reduces emissions of oxides of nitrogen by 80 percent and particulate matter by 90 percent. It also uses up to 37 percent less fuel compared to older switching locomotives.



**Figure 13 Genset Switcher**

### **e. Hybrid Switchers**

**Green Goat**

The "Green Goat" (Figure 14) is similar in concept to the Toyota Prius automobile, which relies on both a gasoline engine and a battery-powered electric motor. The "Green Goat", however, depends entirely on its small, diesel-powered engine to charge onboard storage batteries to provide all propulsion power to electric traction motors attached to each wheel. When energy stored in the batteries is depleted to a pre-set level, a small, low-emission diesel engine automatically starts to power a generator that recharges the batteries.

The Green Goat hybrid locomotive is estimated to reduce emissions of oxides of nitrogen and particulate matter by up to 80 percent, and reduce fuel consumption by at least 16 percent, compared to a conventional switch locomotive." The picture below is for a UP switcher; however, numerous railroad companies use the "Green Goat"



**Figure 14 UP's Green Goat**

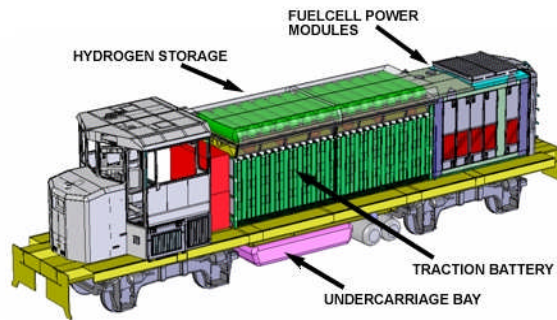
#### **f. Fuel Cell Hybrid**

An industry-government partnership is developing an experimental fuel cell hybrid switcher (Figures 15 and 16) that replaces a "Green Goat" diesel-generator with a 250-kW fuel-cell power plant. Potential benefits of a hybrid powertrain are:

- Enhancement of transient power and hence tractive effort,
- Regenerative braking,
- Reduction of capital or recurring costs,
- Zero emissions and low acoustic noise, while meeting the performance of diesel locomotives,
- Its fuel will be hydrogen, and hydrogen can be produced from many sources, including coal and nuclear energy,
- Fueled by hydrogen, the locomotive itself will emit zero greenhouse gases, and
- Under self-power on rails, it can deliver electricity as backup power for critical infrastructure during grid failures.



**Figure 15 Fuel cell Hybrid Switcher**



**Figure 16 CAD rendering of Fuel Cell Hybrid Switcher**

#### **g. Dynamic Braking Hybrid Locomotive**

General Electric (GE) is designing a hybrid diesel-electric line haul locomotive that will capture the energy dissipated during braking and store it in a series of sophisticated batteries. That stored energy can be used by the crew on demand – reducing fuel consumption by as much as 15 percent and emissions by as much as 50 percent compared to most of the freight locomotives in use today. In addition to environmental advantages, a hybrid will operate more efficiently in higher altitudes and up steep inclines.

According to GE, “the energy dissipated in braking a 207-ton locomotive during the course of one year is enough to power 160 households for that year. The hybrid locomotive will capture that dynamic energy and use it to produce more horsepower and reduce emissions and fuel use.”

#### **h. Advanced Locomotive Emissions Control System (ALECS)**

An experimental technology, ALECS (Figure 17) includes a stationary emissions treatment unit that is connected to diesel locomotives with flexible ducts, and a hood designed to fit over and attach to the exhaust stacks. Diesel-related emissions are captured and treated, rather than being released into the air. UP is evaluating ALECS's feasibility at the Roseville railyard in Placer County, California.



**Figure 17 Advanced Locomotive Emissions Control System**

### **4. Diesel Fuel Regulations**

#### **Ultra Low Sulfur Diesel**

Presently, locomotives that operate in Washington are allowed to use 500 ppm sulfur content diesel fuel. The U.S. Environmental Protection Agency (EPA) has required the use of 15 ppmv sulfur content diesel fuel in nonroad engines (not locomotives and marine vessels) by 2010. However; locomotives and marine vessels are required to start

using 15 ppmv sulfur diesel by 2012. This regulation known as the “Clean Air Nonroad Diesel Rule” was addressed earlier in Section X.

The effect of this regulation will be that the combustion of lower sulfur content diesel fuel will result in a dramatic lowering of sulfate concentrations in the ambient air, which are constituents of fine particulate matter. In addition, sulfates in the presence of water produce sulfuric acid; thus, one would expect less pollution of bodies of water and streams.

The sulfur content in fuels influences degradation of diesel engines because the sulfur tends to produce sulfuric acid in the engines which eats away at the engine parts. One would expect that frequency of maintenance on locomotive engines would decrease because less sulfuric acid will be produced, thus decreasing the wear that the engines experience. A well maintained locomotive will produce fewer emissions to the air, as the efficiency of the engine is greater than when it is not operating at peak efficiency.